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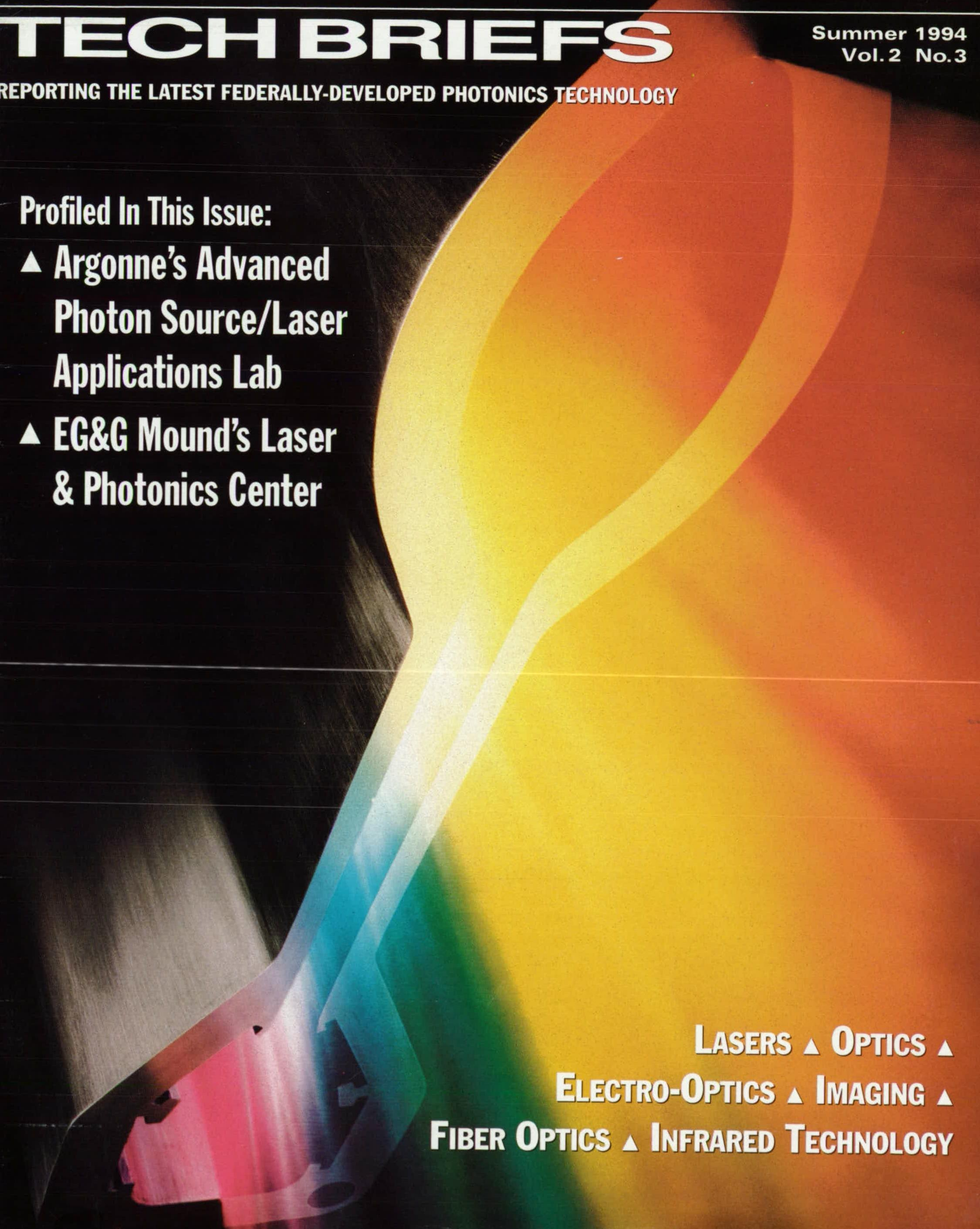
LASER TECH BRIEFS

Summer 1994
Vol. 2 No. 3

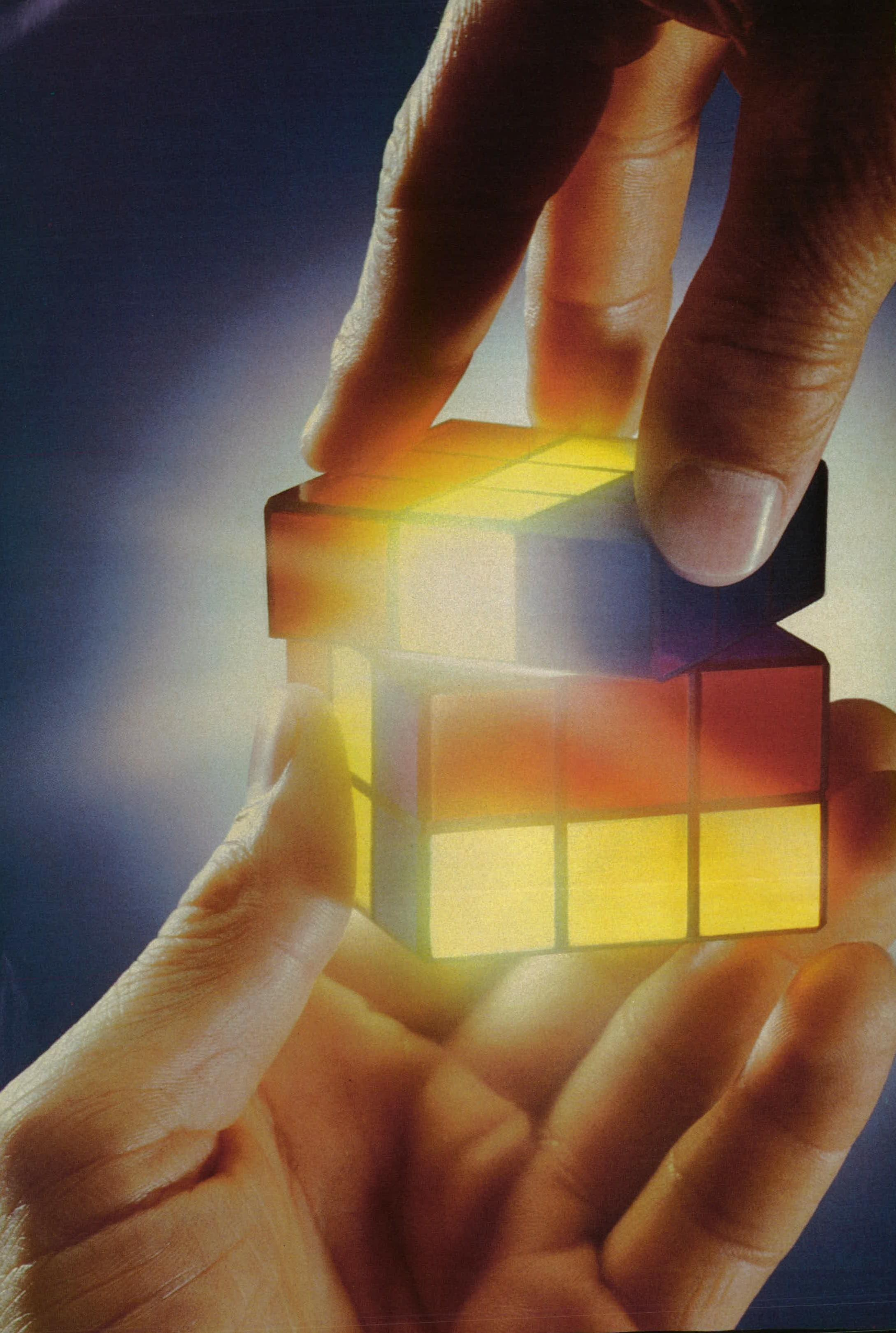
REPORTING THE LATEST FEDERALLY-DEVELOPED PHOTONICS TECHNOLOGY



Profiled In This Issue:

- ▲ Argonne's Advanced Photon Source/Laser Applications Lab
- ▲ EG&G Mound's Laser & Photonics Center

LASERS ▲ OPTICS ▲
ELECTRO-OPTICS ▲ IMAGING ▲
FIBER OPTICS ▲ INFRARED TECHNOLOGY



LASER TECH BRIEFS
SUMMER 1994
Vol. 2 No. 3

CONTENTS

FEATURES

TECHNICAL SECTION

On The Cover:
The Advanced Photon Source at Argonne National Laboratory will begin operations in 1996 as the world's premier source of high-brilliance x-ray beams for research. The beams will be produced by positrons orbiting a two-thirds-of-a-mile storage ring at almost the speed of light. The positrons will travel through a near-perfect vacuum created inside a series of connected extruded aluminum chambers. The photo was created by Argonne National Laboratory Photography Group to represent the concept of light streaming from a vacuum-chamber segment. See the article on page 14.

DEPARTMENTS

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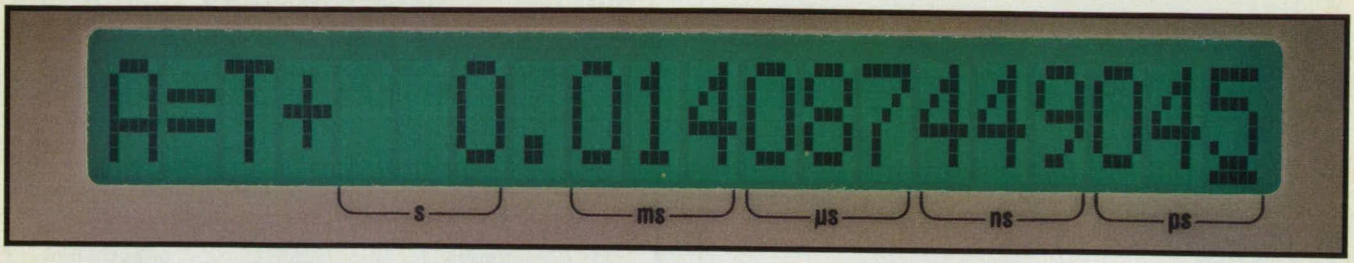

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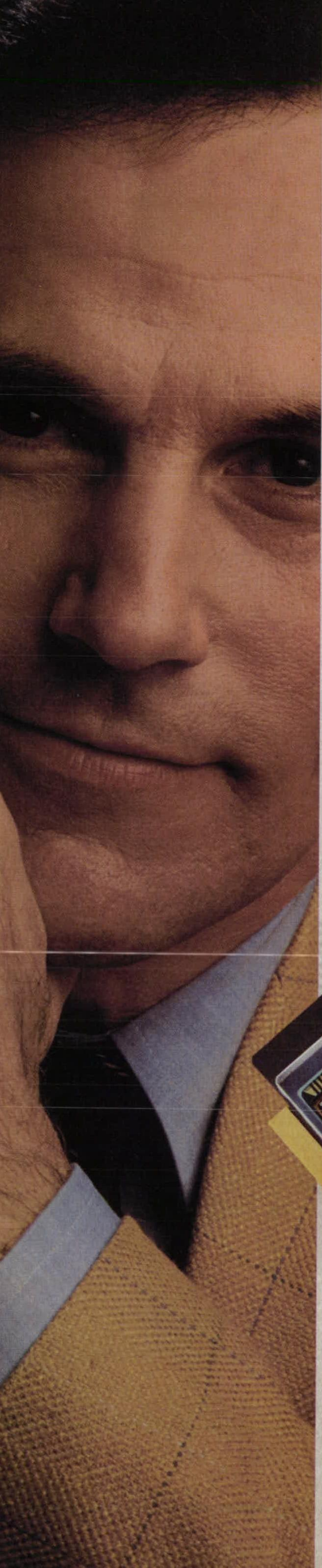

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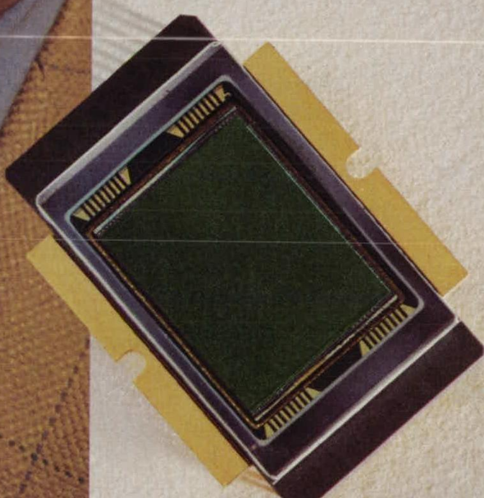

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How You Can Access TECHNOLOGY TRANSFER SERVICES at Federal Laboratories Featured in This Issue

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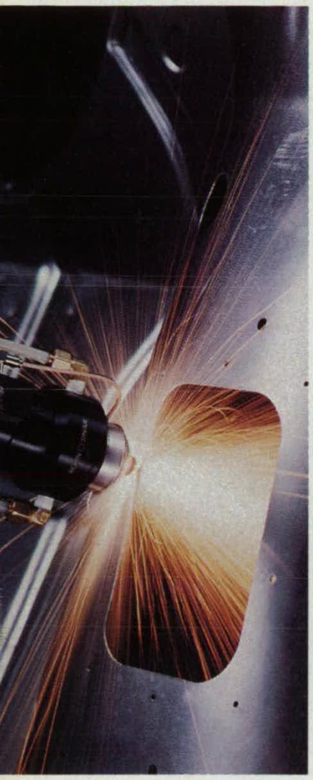
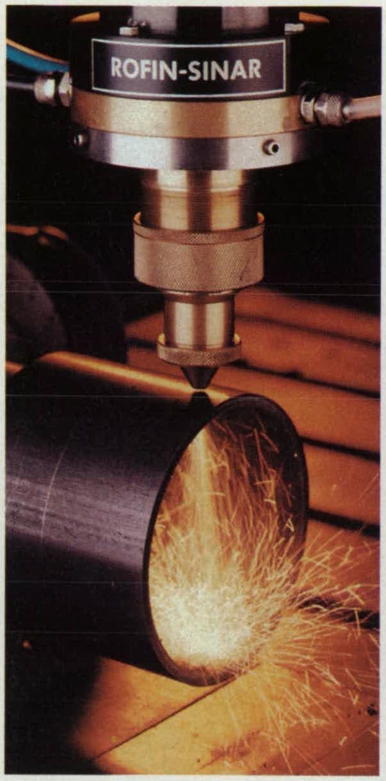
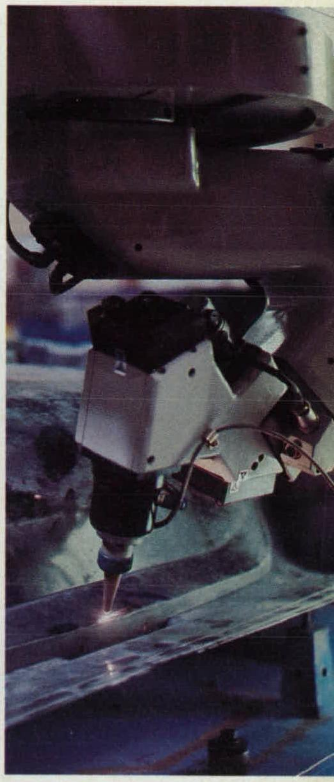
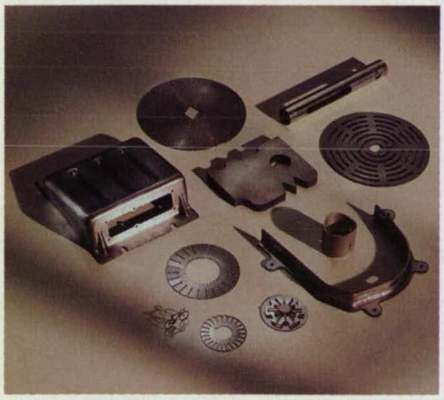






it can also trim some of the fat.



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EDITORIAL NOTEBOOK

Robert S. Clark
Editor

This month I want to use part of this space to call attention to two forthcoming meetings for facilitating transfer of advanced photonic technology out of federal laboratories and into the industrial arena. In September the NASA Goddard Space Flight Center, *Laser Tech Briefs*, and the NASA Northeast Regional Technology Center, with the cooperation of CONNECT, the New England Alliance for Photonics Technology Deployment, will sponsor a one-and-a-half-day Northeast Photonics Commercialization Conference and Workshop in Sturbridge, MA. See the announcement on page 76 for details.

A similar purpose animates LaserTech '94, to be held November 9 concurrently with the Technology 2004 conference and exposition at the Washington, D.C., convention center. Attendees from industry and government will share the technology transfer expertise of a host of speakers from NIST, Ballistic Missile Defense Organization, and other federal agencies. The technical program will present technologies developed in federal centers and available for commercial exploitation. A special pavilion will offer exhibitors the chance to expose products to OEMs and government personnel working in photonics. See pages 67-70 for complete information.

The Army's Space and Strategic Defense Command is offering a unique opportunity to American commercial interests, laboratories, and academic institutions, in the words of their announcement "as part of the national technology transfer program to leverage defense investments to enhance American industrial and technological competitiveness." During the week of September 12, in what it calls the High Energy Laser Light Opportunity (HELLO), it will open up the High Energy Laser Systems Test Facility at White Sands Missile Range (WSMR), NM. As many as 100 experiments will be processed in an assembly-line fashion; participants will be supplied standard diagnostics.

The Mid-Infrared Advanced Chemical Laser (MIRACL) can expose materials to 3.8-micron CW light at total integrated power levels exceeding a million watts over a spot size of 10 cm^2. Costs are expected to be $930 for each test item and $1440 per megajoule of laser energy. In the simplest cases applicants can submit experiments by mail, saving travel costs. Subject to the condition of making HELLO available to as large and diverse a base as possible, selection will go to those who first provide credible funding commitments and also meet safety, environmental, and other requirements. These are specified in the HELLO Experimental Interface Document, which may be requested by providing name, institutional affiliation, area of research interest, address, telephone and FAX numbers, and Internet E-mail address (no telephone calls) to:

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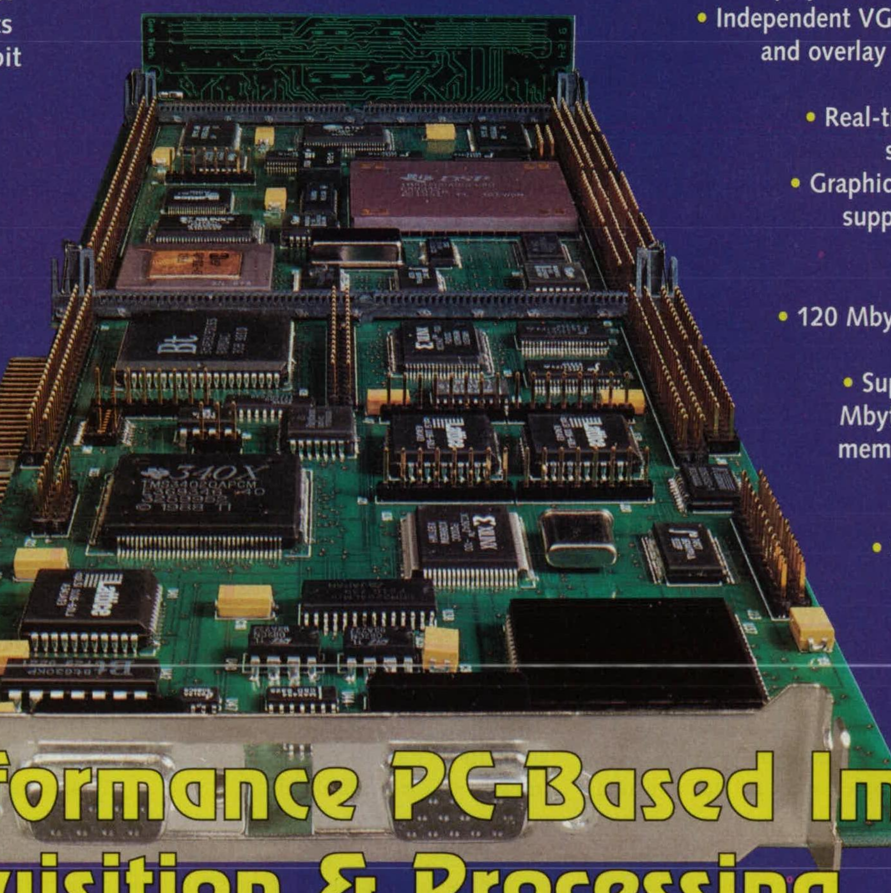

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EG&G Mound Laboratory: Defense Conversion In Action

The Laser & Photonics Center offers partners extensive facilities, qualified staff, and a synergy with other technical disciplines.

BY DR. LARRY DOSSER

EG&G Mound Applied Technologies, in Miamisburg, Ohio, dates from 1948, when it became the first permanent site for Atomic Energy Commission (AEC) projects. It grew in size and technical staff as part of the Department of Energy's nuclear weapons complex to support the fabrication of components for our country's nuclear defense. The work of the past five decades helped bring an end to the Cold War, with a corresponding decrease in the defense programs mission at Mound just as at other sites.

Now the opportunity exists to apply the technologies developed for the fabrication of nuclear weapons components to commercial use. Laser and photonics applications will play a major role in converting Mound to a commercial research, development, and manufacturing site.

Though accomplishing such defense conversion means overcoming numerous obstacles, Mound possesses a unique capability in laser and photonics applications. Lasers are used in a variety of ways, including welding, material processing, high-speed diagnostics, and ultrasensitive spectroscopy, and are complemented by extensive instrumentation in conventional spectroscopies such as the emission, UV-visible, near-infrared, and infrared (FTIR) varieties. Additionally, Mound possesses a wealth of equipment and facilities for recording and diagnosing high-speed/ultrahigh-speed events using various photographic techniques. Rotating-mirror streak and framing cameras, electronic streak and framing cameras, rotating-prism cameras, high-speed video cameras, image intensifier cameras and flash x-ray are all available for recording dynamic events with time resolutions ranging from milliseconds to subnanoseconds.

More important than this extensive capability, however, is the excellent staff of chemical physicists, physicists, engineers, materials scientists and technicians whose skills vary across a spectrum from research and development to manufacturing — a combination that lends itself to the investigation of new applications.

An aerial view of Mound Laboratory in Miamisburg, Ohio. It was named for an ancient Indian burial mound adjacent to the site.

Welding in Many Guises

Mound's welding capability has been demonstrated on fusion welds on closure discs as thin as 0.001 inch, on glass-to-metal sealed assemblies, and on components containing explosive materials (welds within 0.010 inch of explosive powder), as well as on complicated miniature electromechanical devices. Mound's Welding Technology Group developed a filler-wire feed system several years ago for use with the Nd:YAG laser process that can be used with filler wire as small as 0.006 inch in diameter. Mound believes this is the only filler-wire system in use with an Nd:YAG pulsed laser in the country. The laser welding capability, and other welding/joining capabilities at Mound, find numerous applications ranging from the automotive industry to the medical field.

Mound's previous mission in the nuclear weapons complex focused in part on explosive materials. The personnel of the Mound Laser & Photonics Center correspondingly developed unique applications for fabricating components containing these materials, evaluating how these components functioned, and evaluating as well the long-term stability of the explosive materials used in the devices. Although developed for energetic materials, the same capabilities can find numerous other applications in the industrial community.

Two spectroscopic techniques, laser-induced fluorescence (LIF) and laser Raman spectroscopy, are excellent examples of the available resources. The high sensitivity of LIF was formerly used to measure trace quantities of NO_2 evolving from the thermal decomposition of the explosive PETN. This experiment can readily be performed on other materials as well, such as pharmaceuticals.

Sensitive spectroscopic techniques, laser-based and otherwise, are finding increasing application in fields as diverse as environmental monitoring and medicine. Laser Raman spectroscopy has a place in materials research, process control, and the pharmaceutical industry. Mound's emission spectroscopy capability previously was used to assess the chemistry of detonation and laser-materials interaction, but it can also be useful in analyzing any process that emits light. The information in light emission from industrial processes, for example, may yield data suitable for process control.

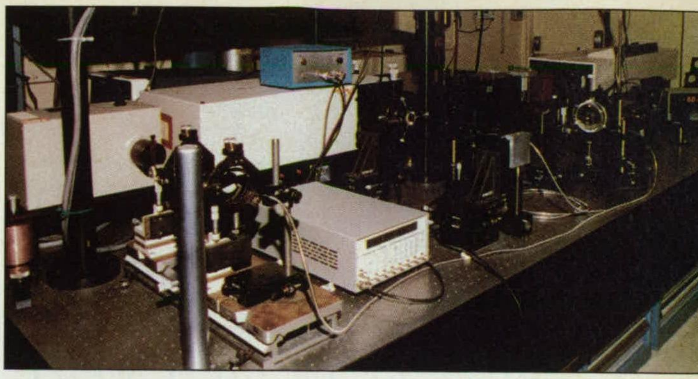
Synergies with Other Disciplines

The greatest strength of the Mound Laser & Photonics Center is its synergistic interaction with other areas of technical expertise at the site. In addition to explosives, these include ceramics, robotics, high-

speed diagnostics, and even nuclear safeguards. A current example of such interaction is the development of a laser-ignited explosive device for the Navy. Laser-ignited devices increase the level of safety of energetic components because the absence of electrical leads eliminates undesired ignition from stray electrical sources. Development of this device has called upon near-infrared spectroscopy, characterization of the laser source, high-speed laser diagnostics, ceramics, fiber optics, beam profiling, explosives, precision machining, and laser welding. Such a combination of critical skills illustrates the synergism characteristic of Mound.

As Mound proceeds with defense conversion activities, more and more applications for the laboratories and skilled personnel will be cultivated. The majority of the laboratories and personnel will be available through a User Center program for industry, enabling access at reasonable cost and through CRADA partnerships. Lasers and photonics represent only one such capability. Others include analytical services such as surface science, physical metallurgy, nondestructive evaluation, and many others. In addition Mound developed a laser hazard awareness program that brought the site into compliance with ANSI Z136.1. This training program could be of considerable assistance to industries and universities that will need to comply with laser safety regulations.

The American taxpayer invested in building Mound, provided it with state-of-the-art equipment, and staffed it with highly qualified personnel. Now this laboratory, and the large investment in it, will benefit U.S. technology and manufacturing. The successful defense conversion of sites such as Mound represents a true "peace dividend" for the American people.



One of the laboratories in the Mound Laser & Photonics Center houses the emission spectroscopy apparatus.

Inquiries concerning the Mound Laser & Photonics Center should be directed to the author, EG&G Mound Applied Technologies, PO Box 3000, Miamisburg, OH 45343; (513) 865-4046; FAX (513) 865-3680; E-mail DOSSLR@DOE-MD.GOV (Internet). EG&G Mound Applied Technologies is operated for the U.S. Department of Energy under contract no. DE-AC04-88DP43495. ■

Dr. Larry R. Dosser is a research specialist at EG&G Mound Applied Technologies.

ARGONNE: PHOTONICS FOR THE FUTURE

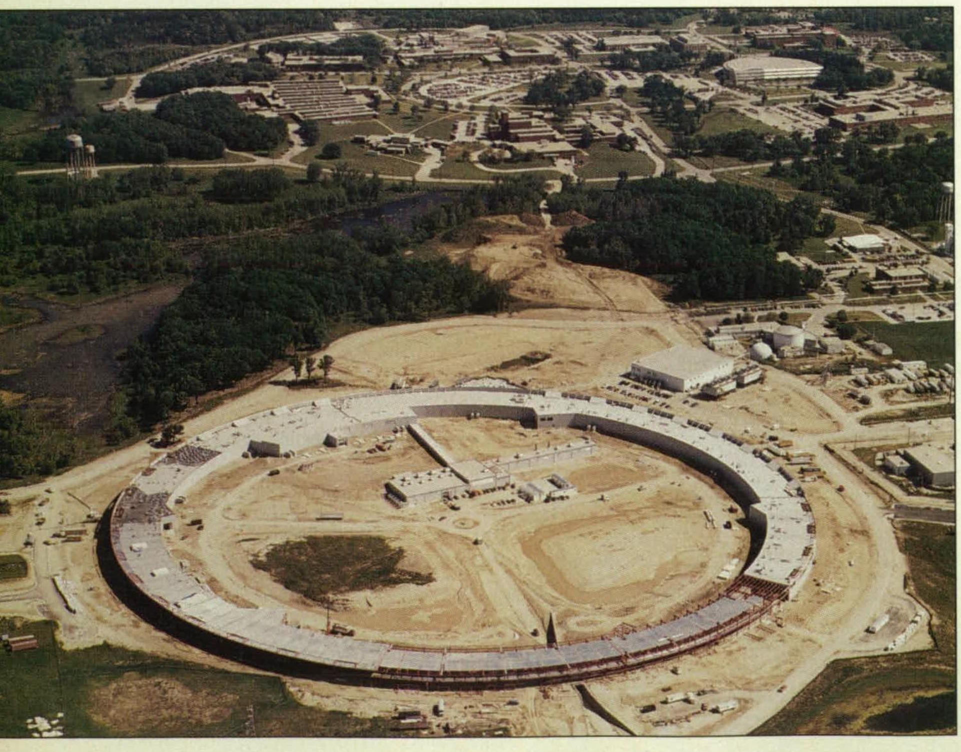
The Advanced Photon Source and the Laser Applications Laboratory put the state of the art in the hands of American industry.

It was the opening of the atomic age that spawned Argonne National Laboratory in Argonne, Illinois, run by the University of Chicago for the Department of Energy. Shortly after the first nuclear chain reaction was observed in the early Forties, Argonne was founded to pursue advanced research and development related to energy issues and technologies. Now, some 45 years later, Argonne is a multidisciplinary research center with a diverse set of programs, ranging from engineering research for advanced energy sources, basic research in physics, materials science, chemistry, mathematics, and computer science, to energy and environmental science and technology.

Along with its main site on 1700 wooded acres about 25 miles southwest of Chicago, the lab has an ancillary division on 600 acres near Idaho Falls, Idaho. Altogether Argonne employs more than 4418 people, 1775 of whom are scientific and engineering professionals. The annual operating budget is more than $450 million.

Apart from its basic and applied research, Argonne actively pursues cooperative ventures with businesses and universities. The lab's diversity enables it to assemble interdisciplinary teams of specialists, and it can offer visiting scientists and engineers the opportunity to use unique research and testing facilities. Argonne signed 17 cooperative research and development agreements in 1993, bringing the center's total to 35. Current agreements include those with Allied Signal Research and Technology, Amoco Corp., Caterpillar, IBM, and Mankato State University/Agricultural Utilization Research Institute of Minnesota.

Argonne also transfers technology by licensing inventions and software directly or through ARCH Development Corp., a University of Chicago licensing arm that has granted more than 40 such licenses and options to private companies. ARCH has also formed four new corporations based on Argonne inventions.



The Advanced Photon Source under construction at Argonne, with the laboratory in the background.

Brightest X-Ray Beams in Prospect

A pathbreaking addition to Argonne's facilities is under construction now. The 7-GeV Advanced Photon Source (APS) is a state-of-the-art synchrotron-light facility

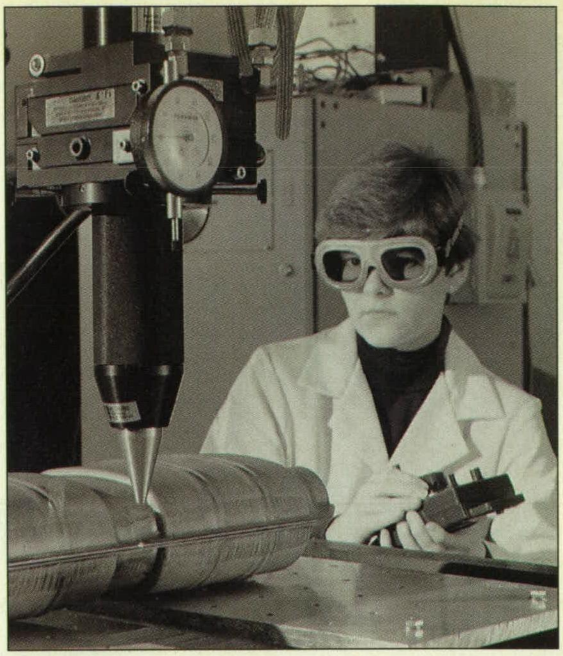
dedicated to the production of extremely brilliant x-ray beams for research. Four years after ground-breaking ceremonies in 1990, work has moved from the construction of buildings to the installation of technical components. The first of four particle accelerators for the \$467-million project, funded by the U.S. Department of Energy, has been installed and tested. Sources at the laboratory say that essentially all technical components are either in production or completed.

When the APS begins research operations in 1997, it will provide scientists with x-ray beams 10,000 times more brilliant than any currently available. Argonne anticipates that about 2000 researchers per year, 300 to 400 at any one time, will make use of the facility.

The APS consists of a series of large electromagnets, an ultrahigh-vacuum system, and many other sophisticated components needed to accelerate positrons — subatomic particles with a positive charge — in a circular path at a speed near that of light. The first accelerator in the series fires electrons at a tungsten target to create the positrons. These are subsequently accelerated to 450 million electron volts and injected into a booster synchrotron. As they travel around this race-track-shaped accelerator, their energies are raised again, this time to 7 billion electron volts, close to the speed of light, in less than one half a second. The positrons are then injected into a circular storage ring located inside the facility's experiment hall. They will travel around the ring, almost two thirds of a mile in circumference, at that speed for several hours. As they do so, they emit synchrotron radiation.

The storage ring and experiment hall will be divided into 34 sectors, into each of which two beamlines will be fed for the purpose of conducting research. One in each pair originates at a bending magnet, which produces radiation that exhibits a broad energy distribution. The other begins at an insertion device, linear arrays of north-south magnets alternating in direction. These devices, which manipulate the positron beam, can be configured two ways: "wiggler" magnets produce very intense, energetic radiation over a wide range of energies, while "undulator" magnets yield radiation of selected energy levels at high brilliance.

When experiments begin at the APS in 1996, 16 sectors will be available to Collaborative Access Teams (CATs) and independent investigators. Argonne recently announced that eight organizations representing national laboratories, universities, and private industry have formed a Synchrotron Radiation Instrumentation Collaborative Access Team (SRI-CAT) to carry out x-ray physics research and to develop novel x-ray instruments. Participants are Argonne, Cornell University, Exxon, the Lawrence Berkeley Laboratory, the National Institute of Standards and Technology, Purdue University, the Stanford Synchrotron Radiation Laboratory, and the University of Houston.



Engineers from Argonne, working with GMC AC Rochester Division, are implementing laser-processing techniques for manufacturing auto exhaust systems.

Some of the projects on SRI-CAT's agenda are a spectrometer for inelastic scattering with millielectron-volt resolution and a microelectron-volt-resolution instrument for nuclear-resonant scattering. The x-ray beams of these devices will be used to study solids and liquids. Another project is a radiation source and beamline with 1 to 4 kiloelectron volts. This beam, with its high intensity, narrow energy range, and controlled polarization, will be a powerful tool for studying materials' electronic and magnetic structures. It is expected to enhance the study of thin films and multilayered materials, which are likely to be at the forefront of the next generation of information-storage media. Another developmental effort will center on lenses that can focus an x-ray beamline to 1000 angstroms.

Better Laser Applications for Industry

The Laser Applications Laboratory (LAL) at Argonne conducts research and development on laser-based applications of materials processing and for aerosol and spray characterization. The general goal of the former is to develop an engineering design database to facilitate the use of lasers in materials processing. More specialized goals include development and optimization of laser processing technology suitable for specific operations on the production floor. Central to these efforts is collaboration with industrial partners.

The LAL facility houses two high-power industrial systems: a 6-kW carbon dioxide laser and a 1.6-kW Nd:YAG laser. Both include diagnostic instrumentation for materials processing functions. The state of Illinois made a \$1.7-million grant to Argonne and its industrial partners for the equipment and the developmental program. Available capabilities include cladding, cutting, drilling, heat-treating, welding, and laser thermal simulation studies. The facility also houses several low-power lasers, including diode lasers from the visible to the near-IR, nitrogen and dye lasers, and HeNe lasers, which are used for characterizing and controlling aerosols and sprays in research relevant to environmental control and fuel-injection optimization.

The LAL is currently involved in several cooperative research and development agreements (CRADAs), structured to be synergistic. Improvements in laser-beam delivery, power measurement, and sensors for on-line processing technology will increase the viability and cost-effectiveness of the high-power laser processing technology current in automotive manufacturing and other industries. Topics currently being researched with industrial partners, among them GMC AC Roches-

ter Division, the United States Council for Automotive Research, Caterpillar, and Spawr Industries, include:

- optimization of laser-beam heat treatment;
- high-speed laser welding of stainless steels for automobile exhaust systems;
- optimization of a laser-beam delivery system and power meter;
- on-line process monitoring for laser-beam welding;
- fiber optic beam delivery for high-power Nd:YAG lasers; and
- optimization of laser cutting parameters for textiles.

Heat treating with lasers allows selective surface hardening against wear with little or no distortion of the component. Because this eliminates much of the part reworking that is currently done, the laser system's capital cost is recovered in a short time. In addition, an inert absorbent coating for laser heat treating that has been developed does away with the fumes generated by conventional paint coatings during the process.

High-speed laser welding is a cost-effective alternative to conventional arc-welding techniques for joining automotive components. The significantly higher production speeds can nullify the higher capital cost of laser systems as compared with metal inert gas or tungsten inert gas systems. Laser-blank welding can increase the structural integrity of the auto's body and reduce its weight.

The LAL is working with a beam-delivery system supplier and a laser manufacturer to develop improved processing tools that use lasers for most cost-effective manufacturing. The delivery system controls the intensity and power delivered to the workpiece. Improvements in beam shaping and control translate into better coupling of the beam energy to the workpiece, resulting in faster, more efficient processing.

Many systems for on-line monitoring of quality have performed well in a laboratory environment but have failed on the production floor. Complexity, susceptibility to the environment, and cost have been the major causes of failure. The LAL has developed a prototype of a simple, rugged, and low-cost process monitoring sensor for laser welding. A collaboration with the automobile industry is under way to demonstrate the system's effectiveness on the factory floor.

The LAL portion of this article was prepared by Keng H. Leong, the technical contact for the Laser Applications Laboratory, Technology Development Division, Argonne National Laboratory, 9700 S. Cass Ave., Argonne, IL 60439; (708) 252-3254; FAX (708) 252-4007. For information on working with Argonne, contact Paul Eichamer, Industrial Technology Development Center, at (800) 627-2596. Cooperative research is supported by the U.S. Department of Energy's Office of Energy Research, Laboratory Technology Transfer Program, under contract W-31-109-ENG-38.

For information about the Advanced Photon Source, contact Paul Eichamer at the number in the paragraph above. ■

ELECTRONIC COMPONENTS AND CIRCUITS

Laser-Ignited Explosive and Pyrotechnic Components

The adaptable devices increase ignition safety and can replace electrical bridgewires in various applications.

EG&G Mound Applied Technologies, Miamisburg, Ohio

During the last decade there has been increasing interest in the use of lasers in place of electrical systems to ignite various explosive components such as detonators, ignitors, and actuators or squibs. These components are used in a variety of applications, from the stage separation of rockets to the deployment of airbags in recent-model automobiles. Present-day components typically function by delivering an electrical signal through lead wires to one or several bridgewires (Figure 1). This is accomplished by sending the signal through a metal pin or pins, which are electrically isolated from each other and the metal shell by an insulating material, usually a ceramic, glass, or glass-ceramic, to the bridgewire. The energy obtained from the bridgewire ignites the energetic material, resulting in the component performing the required operation. In many applications the successful functioning of the component requires the seal to be of sufficient strength to maintain structural integrity and remain leak-tight or hermetic (helium leak rate of <1 X 10^{-8} cm^3/s).

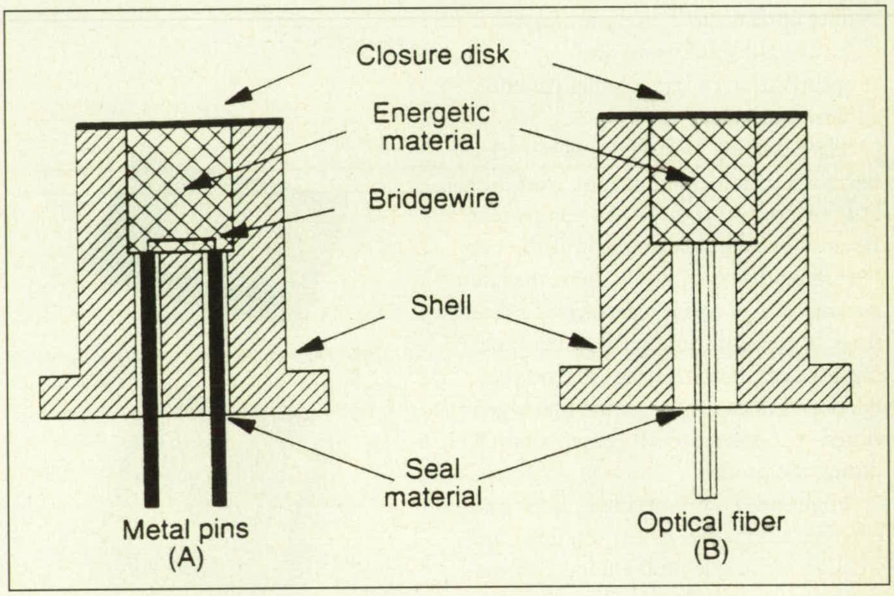


Figure 1. Comparison of cross-sectional views of (A) **Bridgewire Device** and (B) **Laser-Ignited Device.**

Over the years bridgewire devices have been employed in numerous applications despite having several inherent safety limitations. These safety concerns are based on the fact that the explosive or pyrotechnic material is not truly isolated from its environment. This results from the necessity of having an electrical path from the outside world through the insulated pin(s) to the bridgewire. These components are susceptible to the effects of outside electromagnetic pulses and electrostatic discharges such as high-power radar and lightning. Therefore, bridgewire components are capable of undesired ignition that may result in catastrophic personnel injury or property damage.

It is this safety consideration that has been the driving force for the development of laser-ignited components that would be impervious to spurious levels of such radiation and discharges. In many applications laser-ignited components will eventually replace their classical bridgewire counterparts, since the former are insensitive to various high-risk environments. These new laser components incorporate a variety of lasers, including low-power laser diodes and Nd:YAG lasers, which produce sufficient isolated energetic material (Figure 1).

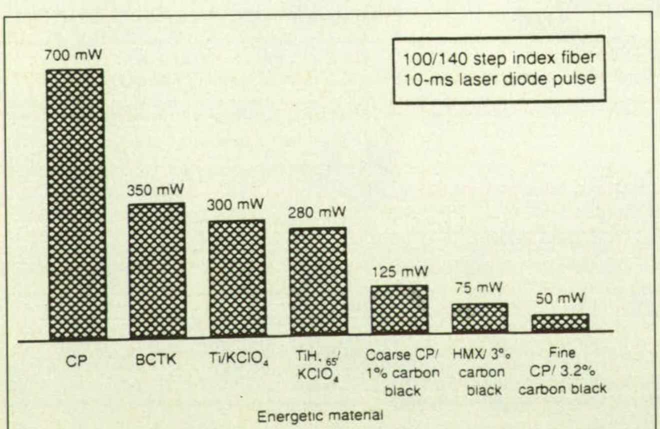


Figure 2. Comparison of the 50-percent all-fire **Ignition Thresholds** (Neyer sensitivity test) obtained on several energetic materials.

Development efforts on laser-ignited components have been directed to three principal areas: determination of the sensitivity of energetic materials to laser energy; development of hermetic sealing processing utilized in the fabrication of components; and design, fabrication, and testing of components. Research on the laser ignition of energetic materials has centered primarily on understanding or measuring the interaction between lasers and these materials. This work has been performed on numerous energetic materials of interest: the ignition thresholds obtained on

several explosive and pyrotechnic materials are shown in Figure 2.

Laser ignition of energetic materials is principally a thermal phenomenon, in which the material absorbs the incident radiation and ignites when it reaches its autoignition temperature. Therefore, the energy required to ignite an energetic material is a function of many parameters, including its thermal conductivity, absorption spectra, composition, packing density, particle size, powder additives or dopants, and blend homogeneity.

The principal difficulty in the fabrication of these safer laser components is the development of sealing technologies that produce seals of adequate strength and hermeticity. This is not a trivial matter, since in most cases seals must be formed with small-diameter optical fibers (fiber pin components) or with thin transparent windows (window components).

Laser-ignited fiber pin components are fabricated using short lengths of optical fiber that function in the same general manner as the metal pins they replace. These components can be designed to have excellent strength characteristics, such as withstanding pressures in excess of ~1300 MPa (~150,000 psi). The difficulty in fabricating fiber pin components has been in developing processing techniques that result in hermetic, crack-free seals between the optical fiber and the sealing glass, and between the sealing glass and the structural member or shell. This is because of the large coefficient of thermal expansion (α) mismatch between fused silica optical fibers (α ~8 X 10^{-7} cm/cm/°C, 25-400°) and the shell material, such as a stainless steel(α ~170 X 10^{-7} cm/cm/°C, 25 to 400°C). The formation of leak-tight, crack-free seals is made possible only by the careful selection of the sealing glass, by the precise control of the time-temperature furnace parameters, and by the development of several novel processing techniques.

Mound also is developing window components. These contain a transparent medium hermetically sealed within the structural member or shell. The window acts as a transparent bulkhead between the optical fiber from the laser and the energetic powder. Window components have one significant advantage over the fiber pin technology, which makes them attractive for application in laser-ignited components: the window diameter is typically many times larger than that of the optical fiber from the laser source. This makes the connection of the fiber to the window component relatively easy and results in laser energy losses that are due only to reflection losses at the fiber-window and window-powder interfaces.

It has been demonstrated that the fabrication of hermetic laser-ignited pyrotechnic and explosive components is possible. This new technology, based on a laser/optical fiber or window combination in place of bridgewires and pins, can readily be adapted to various engineering requirements. Several novel processing techniques have been developed for fabricating the devices that exhibit the required strength and hermeticity to ensure the successful functioning of the device. Several types of laser-ignited components have been fabricated and tested using a variety of diode and Nd:YAG lasers. The function tests have confirmed that laser-ignited components can be reliably initiated with 5 mJ in a 10-ms pulse. The results illustrate that there are no fundamental reasons why laser-ignited components should not be considered for future applications of pyrotechnic and explosive components.

This work was performed by Dr. Daniel P. Kramer at **EG&G Mound Applied Technologies,** *which is operated for the U.S. Department of Energy under contract no. DE-AC04-88DP43495. For further information call Dr. Kramer at (513) 865-3558.*

Low Relative-Intensity-Noise (RIN) Microchip Laser Photonic Sources

Low-noise, single-frequency microchip lasers with output powers of >100 mW are designed for fiber optic distribution networks.

Micracor Inc., Acton, Massachusetts

Fiber optic communication systems that span short distances and have a large number of distribution branches require low-cost lasers with >100 mW output power. Distributed feedback (DFB) diode lasers can provide the single-frequency performance required by communications systems, but they are limited in their output power (approximately 10 mW). Diode-pumped solid-state (DPSS) lasers provide the desired performance, but are generally large in size and costly to mass-produce. Microchip lasers are miniature diode-pumped solid-state lasers with unique properties that allow single-frequency operation, short Q-switched pulse lengths (<1 ns), and an ability to scale optical power using parallel arrays of such lasers. These devices are made using low-cost semiconductor packaging and fabrication techniques.

A microchip laser is fabricated from a wafer of a solid-state gain medium (Nd:YAG in this case), which is polished flat and parallel, and dielectrically coated on both sides (Figure 1). Single-frequency operation is obtained by making the cavity length short enough that the longitudinal mode spacing of the cavity, $\Delta\nu_g$, is greater than the gain bandwidth of the laser medium, $\Delta\nu_c$, as shown schematically in Figure 2.

In general, a flat-flat laser cavity is a marginally stable resonator; a perfect flat-flat cavity would lead to an infinitely large laser spot size. In the microchip laser, heat that is deposited by the pump laser diode in the gain medium generates a thermal lens that stabilizes the spatial mode. The lasing frequency of a microchip device can be tuned by changing its temperature; for Nd:YAG lasers, the frequency change with temperature is approximately 2.8 GHz/°C.

The single-frequency CW power of a microchip laser can be optimized by adjusting the frequency of the microchip such that the lasing longitudinal mode is aligned with the peak of the gain profile. Temperature-optimized 1.3-μm Nd:YAG lasers have been constructed using a thermoelectric cooler to control the ambient temperature of the microchip. Approximately 200 mW of single-frequency power have been obtained using this technique. Of this

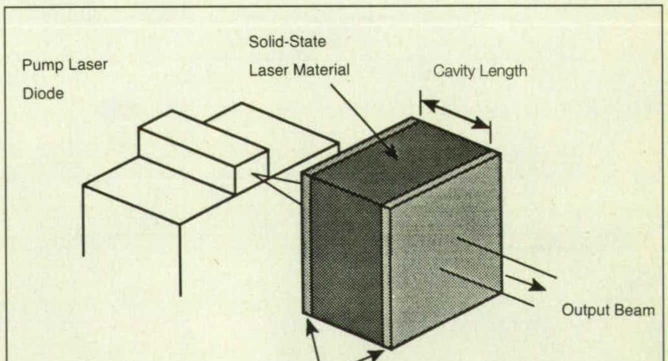
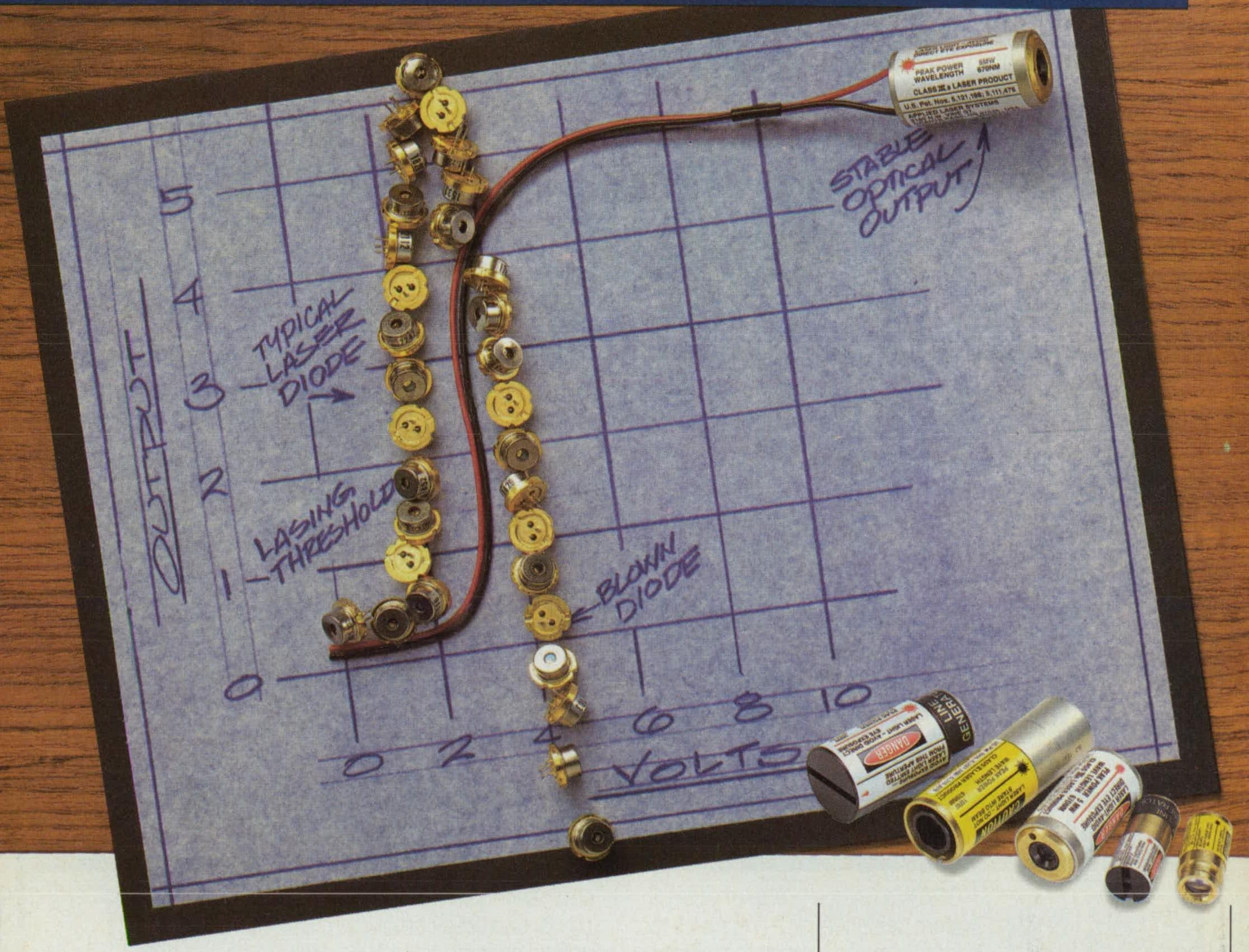


Figure 1. A **Microchip Laser** consists of a miniature monolithic flat-flat solid-state cavity longitudinally pumped by a diode laser. The mirrors, which provide the feedback necessary for laser oscillation, are directly deposited on the optically polished surfaces of the solid-state gain medium.

What Goes Up, Usually Comes Down...



Unless

...the laser diode destined for your product application is completely protected against the forces of electro-static discharge, temperature and handling abuse. That's because a raw laser diode is a fragile and highly volatile device with extreme threshold behavior that will quickly "blow up" under unstable environmental conditions. The typical laser diode is capable of turning on in "one millionth" of a second...and one very short "mistake" usually results in total destruction, rendering the laser diode useless. Applied Laser Systems (ALS) has solved this problem and makes the laser diode usable in the real world.

So, while it may seem practical to engineer your laser product "from the ground up," it makes far more sense to bypass the frustrating process of trying to stabilize the laser diode by simply "plugging in" our patented VLM™ product directly into your application. Our modular system is so user friendly, all you have to do is add a power supply.

Simply put, the ALS Visible Laser Module, or VLM™ product is the most advanced laser module system on the market today. Our miniature design incorporates the laser diode, drive circuits, and sophisticated optics into one tiny, self-contained, shock resistant package, allowing us to maximize power efficiency while protecting the internal circuitry from electro-static discharge, spiking overload and reverse polarity. In short, the VLM™ product makes the fragile laser diode virtually indestructible.

*And with a field failure rate of less than 1 percent, Applied Laser Systems supports its products with a full **two year warranty,** setting the industry standard. In addition, a small green LED indicator is mounted on the rear of each module to indicate when the laser is operating...a safety factor that ALS alone provides.*

The versatile VLM™ product comes ready-to-use in a variety of beam configurations and wavelengths, in both the visible and infrared bands. Modules can easily be integrated into a wide variety of applications that require precision and accuracy, such as alignment and positioning, counting and timing, signal transmission, testing and measurement, and illumination... right out of the box.

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power, >100 mW have been coupled through an optical isolator into a polarization-maintaining fiber.

Feedback circuitry has been constructed to monitor the noise spectrum of the microchip laser. A beamsplitter captures a small portion of the beam and directs it to a photodetector. The resulting error signal controls current to the pump diode. Small signal modulation of the pump diode intensity (with the proper phase and gain) effectively reduces the microchip laser RIN spectrum. Reductions of -38 dB have been achieved at the relaxation oscillation using this technique.

Low-noise microchip lasers have been successfully integrated into compact high-speed (18-GHz) optical links. For Rome Laboratory, the pump laser has been remotely located from the microchip element, allowing for pump-source replacement with a long lifetime.

This work is being performed under contract by Dr. James Keszenheimer and Dr. Kevin Wall of ***Micracor Inc.*** *for Rome Laboratory, Photonics Center (Program Manager E. Walge). Micracor owns exclusive license to this invention. Inquiries for further information or as to its use should be addressed to Micracor Inc., 43 Nagog Park, Acton, MA 01720; (508) 263-1080.*

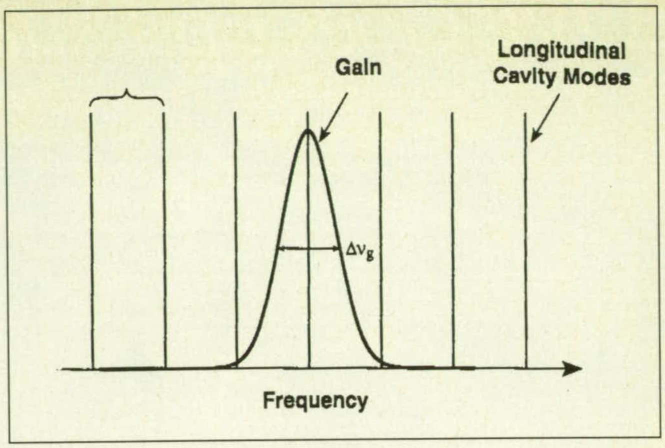


Figure 2. **Laser Gain Curves and Cavity Modes** of a microchip laser. To achieve single-frequency operation the length of the cavity, *l*, is chosen such that the spacing of the longitudinal modes, $\Delta\nu_c$, is greater than the gain bandwidth of the laser medium, $\Delta\nu_g$.

Multichip-Module Optical Interconnects Step Up Bus Performance

A 16-channel interconnect can easily be fashioned in low-cost stable components.

Rome Laboratory, Photonics Center, Griffiss Air Force Base, New York

Optical interconnects have been promoted as a solution for a range of computer bus applications. But the slow development of stable electro-optical components and the high cost of inserting a new technology into an established product demands that a drastic improvement in performance be demonstrated before optical interconnects are accepted as a manufacturable technology. An insertion point that promises such an increase in performance is the multichip-module-to-

multichip-module (MCM-to-MCM) data bus.

MCMs are rapidly becoming the platform of choice for computer architectures, from specialized military systems, including satellite processors, guidance control, and aviation systems, to commercial applications ranging from medical and automobile computers to super- and mainframe computer systems. MCMs address the chip-to-chip data transfer delays and power costs typical of PC-board technology. In the MCM, bare dies are placed close to and connected with fine metallization runs, greatly reducing the impedances associated with the long runs connecting packaged dies on traditional computer boards. The resulting module represents a small (typically 4-X-4-inch), densely populated and high-speed computer "board." For complex applications, a number of MCMs must be interconnected with a massive number of high-data-rate channels. Optical interconnects are ideally situated to provide this bus function.

Electronic MCM-to-MCM connections are typically routed to the outside of the MCM, with the plane-to-plane connection made on the edge of the stack of MCMs. The connections must be relatively large to overcome mechanical and environmental stresses. The long length and high impedance of these contacts result in a slow and power-hungry interconnect that is limited in the total number of connections by the real estate of the edge of a 4-X-4-inch MCM.

Optical devices can provide much faster interconnects, in greater numbers and density, between MCMs. Long wires are replaced by optical beams that do not suffer the impedance limitations that make for slow data rates and large power consumption. Optical approaches also permit easy disassembly and reassembly of the MCM stack, because no hardwired electronic connections have to be cut and reestablished. The optical signals can be sent through transparent MCM substrates, such as 1.3- or 1.5-μm-wavelength light through Si) or through holes etched in nontransparent substrates, such as alumina or AlN_3. Integration of optical transmitters and receivers with traditional Si circuitry is a natural extension of the MCM package. Individual bare dies, regardless of material, are placed next to each other on a third substrate and connected with high-speed electronic wires.

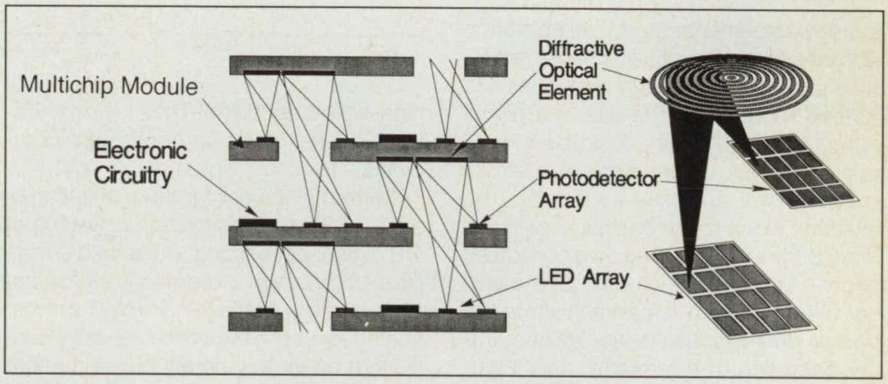
The figure shows an example of one such optical interconnect architecture. The light from an array of light-emitting diodes (LEDs) travels through a hole in the MCM above it, is redirected and focused by a single diffractive optic element (DOE) placed on a third MCM, and is imaged onto an array of photodetectors on the middle MCM. Each LED is mapped to an individual photodetector, creating a single channel on the 16-channel bus. This architecture has the advantage of utilizing low-cost, easily fabricated, and technologically stable components for use in near-term interconnect applications. A 16-channel plane-to-plane interconnect was demonstrated using this configuration.

Critical design parameters of the components used in this interconnect were ease of fabrication, use of standard substrates, and low cost. High-performance vertical cavity surface-emitting laser (VCSEL) arrays were not used because of their high cost and operating complexities, and the lack of a suitable commercial supply at this time. In comparison, GaAsP homojunction LEDs are relatively easy to fabricate, have high yields, and are inexpensive. The large divergence of the LEDs was compensated for by the focusing ability of the high-efficiency (more than 75 percent diffraction efficiency) DOE, which consists of an eight-level phase relief pattern etched in a silicon substrate. Gold was evaporated on the Si surface to enhance the reflectivity of the DOE. Silicon metal-semiconductor-metal (MSM) photodetectors were used to collect the 655-nm light from the LEDs.

Spacing from the top of one MCM to the top of the next was defined as 3 mm. A less than 1-mm hole is used to allow the light from the LEDs to pass through the middle MCM and strike the 1.1-mm-diameter DOE. The LEDs are 50 μm X 50 μm and spaced on 200-μm centers. The image of the LEDs that strikes the photodetectors is demagnified by a power of 0.5 by the DOE. The photodetectors are 75 μm X 75 μm on 100-μm centers, allowing for a 25-μm (1-mil) displacement in the X and Y axes. System alignment tolerances are factored into LED and photodetector size and spacing.

The DOE was able to clearly image the LED emission onto the photodetector array. Some image blurring was expected, and was verified, because of the non-monochromatic nature of the LED sources. DOEs are mathematically generated patterns that take into account source and detector placement and the wavelength of the source. Light of other wavelengths will be focused at different points along the conjugate axis of the DOE, creating a slight blurring of the image. The crosstalk from an LED image incident on a "nearest neighbor" to a photodetector was -34 dB (electrical signal) below the signal on the target detector.

As computer speeds get higher and higher and chip input and output pins increase in number and density, new techniques will have to evolve to take data from chip to chip and computer board to computer board. The rapidly growing MCM technology addresses the high-speed and high-density requirements for in-plane data transfer. However, electronic solutions for plane-to-plane data bus problems have not provided suitable data rates, interconnect numbers, densities, and power consumption levels. Optical interconnect components and architectures are coming of age. Low-cost arrays of emitters and detectors can be manufactured easily and individual devices spaced to meet the alignment tolerances of die placement and MCM-to-MCM alignment equipment. Diffractive optics etched in low-cost substrates can perform complex focusing, redirecting, or splitting functions. Computer systems utilizing optical interconnects will be limited in operating speeds by chip speeds and not by the limited bandwidth of the data-bus technology.



Plane-to-plane **16-Channel Optical Interconnect Scheme** for stacked multichip-module computer systems using LED and photodetector arrays and a single diffractive optic.

This work was done by F. Haas, D. Honey, and H. Bare of **Rome Laboratory** *in collaboration with H. Craighead, Steven Shanck, and D. Mikolas (now of nano-Optics, Ithaca, NY) of Cornell University. No further information is available. Inquiries concerning rights for commercial use of this technology should be addressed to Rome Laboratory, Office of the JA, Griffiss AFB,, NY 13441.*

Self-Routing Optical Interconnect

A self-routing packet switch using holographic optics will reduce costs of future interconnects.

Rome Laboratory, Photonics Center, Griffiss Air Force Base, New York

Supporting an ongoing in-house program to develop optical interconnects for wafer-scale and multichip-module radar signal processors, an allied effort has resulted in a new and highly promising self-routing approach. Future advanced signal processors will involve high-speed data routing within the computer, and between processors in a parallel processing architecture, via optical interconnects. Techniques to allow the data stream, in the form of optical packets, to route itself to proper destinations are required for high-speed operation.

Recently, a working-prototype packet router was demonstrated. The approach abandoned an all-optical scheme requiring the use of bulky optical delay lines and instead focused on the use of a digital optical associative memory implemented using a 2 X 4 hologram array. Header bits in the packet are used as input to the memory, which triggered optical switches to properly route the data. In a scheduled follow-on effort, an electronic buffer memory will be used to temporarily store the packet during optical associative memory decoding of the header bits. Electronics can conveniently store the packet in a compact fashion during decoding, while the optical memory provides for very high-speed decoding. Thus the best features of electronics and optics are combined.

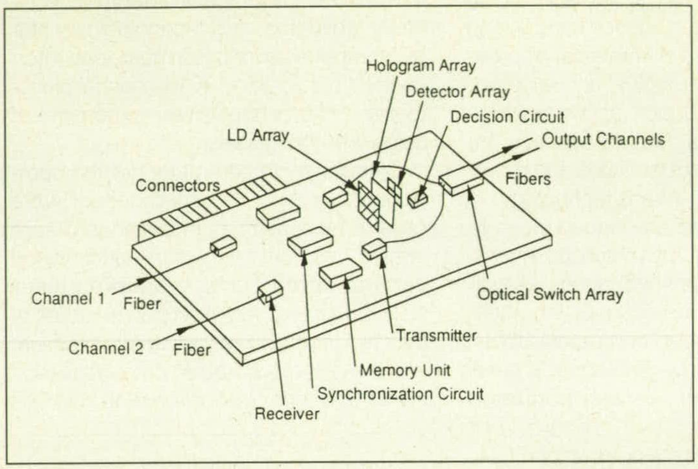


Illustration of a **Self-Routing Switching Node** on a single board.

Current plans call for the fabrication of a 32 X 32 switching system operating at 0.8 gigabit per second. Advanced smart-pixel technology, integrating optical and electronic devices together, may be investigated for use in the optical memory subsystem under a separate planned effort. It is expected that this research will result in dramatically improved optical interconnect approaches for use in Air Force processors for radar space-time signal processing and intelligence data classification applications.

This work was performed by POC Inc. in a Small Business Innovative Research (SBIR) effort directed by Joanne Maurice, **Rome Laboratory,** *Photonics Center, Griffiss AFB, New York. No further information is available. Inquiries concerning rights for the commercial use of this technology should be addressed to the Patent Counsel, Office of the JA, Griffiss AFB, New York, NY 13441.*

'Micromirror' Optical Fiber Chemical Sensors

Devices offer the potential of a simple, inexpensive way of detecting a wide range of chemical species.

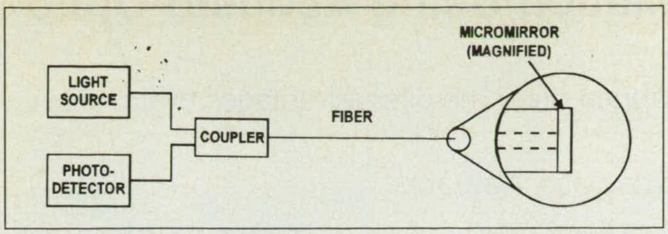
Sandia National Laboratories, Albuquerque, New Mexico

"Micromirror" optical fiber sensors represent a simple concept that possesses broad practical applications. The technology applies chemically sensitive coatings to one end of an optical fiber. In operation, the coatings change their optical properties when exposed to the desired chemical species. Thus, one need only monitor the amount of light reflected from the coated fiber end for detection. The art of the technique lies in proper selection of the applied coating, as the sensitivity, selectivity, and speed of response of the sensor is determined by the coating's chemistry. This technology is particularly straightforward to manufacture, as selected coatings can be applied through any of a variety of techniques, while the rest of the system utilizes commercially available optoelectronic components developed for optical communications.

Optical fiber sensors offer a number of unique advantages: ease of multiplexing and telemetry of the signal over long distances, immunity to electromagnetic interference, and very small size. For these reasons, optical fiber sensors are particularly advantageous for certain environments, including in-ground monitoring of pollutants, measurements in electrical utility applications, and situations where minimal intrusion of the sensor is desired, such as selected biomedical applications.

By changing the coating, the sensor can be used to detect a wide variety of chemical species. The versatility of this technique has been demonstrated at Sandia by detecting hydrogen using palladium coatings, volatile organic compounds using polymer coatings, and oxidants using a variety of coatings. In principle, a coating can be found to detect any species. Biologically active coatings could be used to detect chemical species important to biological processes, for example. The coatings range in thickness from 10 nm for metallics to a micrometer or so for optically transparent coatings. The small size of the multimode optical fiber, typically diameters of 50 µm core/125 µm cladding, combined with the thinness of the coating means that the sensing volume is very small, between 10 and 1000 cubic micrometers. Thus the sensor is sensitive to a very small number of molecules and need only sample small quantities of material. As few as one billion molecules of a volatile organic compound have been detected. The use of smaller fiber cores and/or higher optical powers should make it possible to detect the presence of fewer than one million molecules of the desired species.

The micromirror technology is going to Mars on a Russian spacecraft due to launch in 1996, to study the chemical reactivity of the Martian soil. A large number of



Schematic illustration of Sandia's **Micromirror Chemical Sensor**. Commercially available optoelectronic communications components are converted into a system for chemical detection by forming a thin mirror (typically 100 angstroms) on the exposed end of an optical fiber through the application of selected chemically active coatings. The coating changes reflectivity on exposure to the chemical of interest, and thus provides a mechanism for sensing desired species at long distances. Examples include: Au for Hg detection, polymers for organic vapor detection, Ag for H_2S detection, and Pd for H_2 detection.

coatings have been developed for the detection of oxidants in the Martian soil and to study the erosion of organic materials in its environment. Understanding the soil chemistry of Mars is of great importance to future missions, as crude tests from NASA's Viking lander in 1976 suggested that the Martian soil contains reactive species including strong oxidants such as hydrogen peroxide. For that reason, the soil chemistry could pose severe degradation problems for future landing craft, rovers, and astronauts' equipment. This new instrument, being developed in collaboration with NASA/JPL, will weigh less than a kilogram, will be completely self-contained as far as power and data acquisition are concerned, will have an operational life approaching a year, and will monitor 256 fiber sensors simultaneously. The requirements of low weight, small volume, and low power for this space mission are also desirable characteristics for remote sensing on earth. The 256 fiber sensors represent the largest number of sensors that have ever been simultaneously monitored in a single array. This application of the optical fiber chemical sensor provides the ultimate demonstration of remote sensing with the instrument many millions of miles distant. Back on Earth, the same chemical sensor is being investigated by U.S. firms as a leading candidate for monitoring industrial environments.

The micromirror optical fiber chemical sensor offers the potential of a simple, inexpensive device that can respond to a wide range of chemical species. By combining commercially available components with an easily deposited coating to create the sensing element, these devices will be small and portable as well as suitable for remote monitoring, as illustrated by the Mars instrument. Such sensors can significantly affect the problems encountered in manufacturing, in environmental monitoring, and in cleanup.

The work was done by M. A. Butler, A. Ricco, and K. B. Pfeifer of **Sandia National Laboratories**, *a participating member of the Alliance for Photonic Technology. For further information contact Mike Butler at (505) 844-6897 or Jamie Wiczer at (505) 844-5672, or write to them at the Microsensor Research and Development Department, Org. 1315, M/S 0351, Sandia National Laboratories, Albuquerque, NM 87185, or alternatively to the Alliance for Photonic Technology, 851 University Blvd. SE, Bldg. 1, Suite 200, Albuquerque, NM 87106-4339; (505) 272-7001.*

A patent on this work has been applied for. Inquiries about commercialization through licensing or CRADAs should be addressed in writing to Angelo Salamone, 10520 Research Rd., SE, Albuquerque, NM 87123-1380.

Wideband Active Noise Cancellation Using Acousto-Optic Devices

An acousto-optic time-integrating correlator and tapped delay line offer advantages over digital signal processing approaches.

Rome Laboratory Photonics Center, Griffiss Air Force Base, New York

With the advent of the acousto-optic deflector (Bragg) cell, numerous optical correlator architectures have been made possible. The anti-jamming optical beam-forming (AJOB) program under way at the Center's Analog and Lightwave Photonics Branch has been established to consider some of these architectures and apply them to the problem of active noise cancellation for radar signal processing. These Bragg cells are also well suited for use in a delay line, which can form an estimate of the uncorrelated noise in some signal of interest.

An optical correlator can be constructed as shown in Figure 1. A laser illuminates a Bragg cell driven by a noisy signal. (The direction of signal propagation in the first cell is indicated by the unshaded arrow.) The second Bragg cell is illuminated by the undiffracted light from the first (which satisfies the Bragg condition of the second), and is driven by multiple time-delayed copies of the noise source. (The direction of signal propagation in the second cell is indicated by the solid black arrow.)

The light diffracted from the first cell passes through the second, since it does not satisfy the Bragg condition. A zero-order block prevents the undiffracted light from travelling any further. The two diffracted orders are interferometrically recombined at the detector array and, due to the orientation of the Bragg cells, are counterpropagating. The linear detector array integrates over a software-selectable range of 5 ms-40 ms to detect the image. When the counterpropagating diffracted orders recombine, their correlation forms, and a digital computer reads and processes it.

The Dove prism in the imaging system between the two Bragg cells is used to spatially invert the diffracted order from the first cell. This is necessary because at the first cell's focus in the imaging system the diffracted order is spatially inverted, and if allowed to propagate through this system as is the two diffracted orders would not be counterpropagating. If the orientation of either of the Bragg cells were reversed, the diffracted orders would counterpropagate, but they would not overlap at the detector plane.

This architecture has successfully performed autocorrelations of a 1-μs pulse on a carrier ranging from 60-100 MHz. The Bragg cells are 8-channel Brimrose acousto-optic deflectors with a 5-μs aperture. The digital computer determines the location and amplitude of the correlation within the aperture of the linear detector array.

This information is passed to a second optical subsystem, the acousto-optic tapped delay line shown in Figure 2. A diode laser array, each element of which can be independently amplitude-modulated (currently being tested), will illuminate different locations of the Bragg cell corresponding to a delay in its 5-μs aperture. These are the tap locations of the noise in the main channel.

The diffracted orders from the Bragg cell are heterodyned with the undiffracted light, and the noise estimate is heterodyne-detected at the detector plane. This estimate is then electronically removed from the

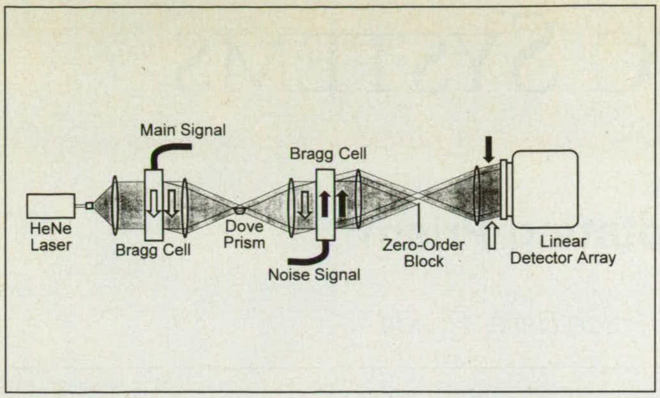


Figure 1. **Optical Time-Integrating Correlator** architecture.

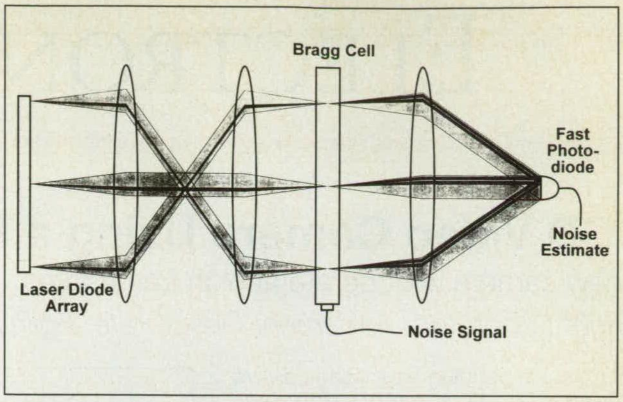


Figure 2. Proposed **Acousto-Optic Tapped Delay Line**.

main channel. The new main signal is fed back into the correlator to see how good the noise estimate is. This noise-reduction algorithm thus becomes a gradient descent style problem, where the noise estimate is continually refined until some acceptable level is reached.

This approach offers some intriguing advantages over the more traditional digital radar signal processing algorithms. Primarily, because of the massively parallel processing inherent in optics, correlations are performed in the amount of time required for the linear detector array to integrate (8 ms with the equipment currently being used; faster cameras are available, however). Additionally, since the noisy signals are generally analog in nature, staying in the analog domain gains an advantage in speed. In the test setup presented here, the signals are brought into the digital domain for analysis purposes. Other approaches offer the possibility of performing all analog signal processing and cancellation by creating a grating in a photorefractive crystal.

While the AJOB project is looking at problems related to radar signal processing, specifically jammer cancellation, there are a number of possible commercial uses for these approaches. For instance, in obstetrics, a physician must listen for a fetus's heartbeat while the mother's body is making all kinds of noises of its own (heartbeat, respiration, digestion, etc.). These noises could be suppressed by placing a number of auxiliary acoustic sensors on the mother's body and correlating them with the signal intended to read the baby's heartbeat. Similar approaches could be applied to the problems of aircraft, automobile, and industrial noise suppression.

This work was done under the supervision of Capt. Harold Andrews, Lt. Michael Turbyfill, and Capt. Christopher Keefer with development sponsorship by **Rome Laboratory**. *No further information is available.*

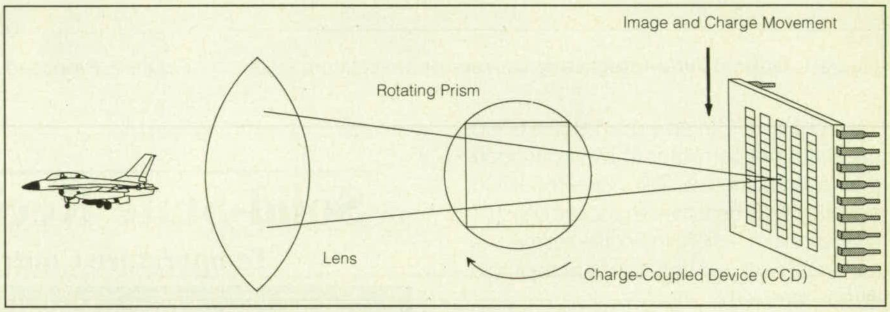
Inquiries concerning rights for commercial use of this technology should be addressed to Rome Laboratory, Office of the JA, Griffiss AFB, New York 13441.

CCD Video Camera Using a Rotating Prism

A new camera will operate at high frame rates.

Wright Laboratory Armament Directorate, Eglin Air Force Base, Florida

A patent is pending on a video camera especially suited for high frame rates using charge-coupled devices (CCDs). The advantage of CCDs in general is that they have a simple readout structure and large pixels that provide high sensitivity and fill factor, the latter denoting efficient use of die area. The result is higher die yields and lower noise because of lower capacitance and resistance in the electronic paths and increased charge-transfer efficiency.



Basic concept of the **Rotating-Prism CCD Video Camera**.

But these imagers have an inherent blurring problem, resulting from continued image exposure while the charge is being read out. This problem is commonly resolved by quickly moving the charge under a shielded area. One technique transfers the charge into a frame area consisting of shielded columns located at the end of the light-sensitive columns. The imager incorporating this technique is called a frame-transfer CCD (FT-CCD). Another technique uses shielded columns located between the light-sensitive columns, and the imager is called an interline-transfer CCD (IT-CCD).

The disadvantage of the FT-CCD is that the readout of the pixels to the shielded frame area must be done in a time much shorter than the exposure time. This becomes more difficult at higher frame rates because the charge-transfer process

is limited by the bandwidth of electronic circuitry, especially with high-resolution imagers. IT-CCDs require additional area between the columns of pixels, reducing fill factor. In both devices, the fabrication yield is lower because of the larger semiconductor die needed versus a full-frame CCD that does not use a shielded area.

The invention uses a rotating prism in conjunction with a full-frame CCD to eliminate the blurring. In the figure, an illustration of the basic concept of the system, a lens is used to focus an image on the CCD. As the prism is rotated, the image is bent and thus moves along the CCD surface. At the same time, charge in the pixels is transferred down the columns synchronously with movement of the image. In this way, the blurring of the image that is inherent to the readout mechanism of CCDs used as a staring array is eliminated.

The invention is analogous to the rotating-prism film cameras already being used today. The main difference is that the film is replaced with a CCD. A color-camera version can be made by the use of a vertical stripe filter. The colors of the filter are aligned in columns in the same direction as charge movement in the CCD. In this way, the color information is maintained as the charge is moved from pixel to pixel. This technique for providing color can also be used in machine-vision systems.

An additional advantage of the invention is that pixel-to-pixel nonuniformities are averaged out over each of the transfer columns. This makes compensation of fixed pattern noise easier, since adjustment is only needed for each column rather than for each pixel. Also, the readout circuitry is simpler, since only a constant pixel-to-pixel charge-transfer clocking scheme is needed. The step of transferring charge to the shielded areas is no longer necessary.

A prototype has been built using a Sierra Scientific machine-vision camera, Photosonics rotating-prism film camera, and an EPIX frame grabber. Operating at 30 frames per second, it was built primarily to prove the concept. Currently, improvements to the prototype are being made. A stepper motor is being added for better control of the prism and synchronism with the CCD imager, and a faster CCD imager and frame grabber are being obtained for experimentation at higher frame rates.

This work is being done by Rodney M. Powell at the **Air Force Wright Laboratory Armament Directorate**, *Eglin Air Force Base, FL 32542. Inquiries concerning rights to and patent status of this invention may be addressed to Mr. Powell at (904) 882-9910, ext. 1290, or alternatively to Jerry Jones, Office of Research and Technology Applications; (904) 882-8591.*

Characterization of Pyrotechnic Igniters by Laser-Illuminated High-Speed Photography

The technique can be applied to many energetic materials.

EG&G Mound Applied Technologies, Miamisburg, Ohio

Measurement of burn rate, function time, and output properties of components utilizing explosive and pyrotechnic (energetic) materials are of primary importance in characterizing not only the reactions of these materials, but also in evaluating the effect of component design changes. High-speed photography at rates of up to 20,000 images per second was used to measure these properties in pyrotechnic igniters. By synchronizing a copper vapor laser to the high-speed camera, laser-illuminated images record details of the performance of a component in a unique fashion. The output characteristics of several types of hermetically sealed igniters using a $TiH_x/KClO_4$ pyrotechnic blend were measured as a function of the particle size of the pyrotechnic fuel and the closure disk conditions. The igniters were filmed under both ambient (i.e., unconfined) and confined conditions. These igniters are used to ignite thermal batteries, and recently the function of the igniter in a model thermal battery has been filmed at Mound.

Two compositions of the pyrotechnic blend, either 33-percent TiH_x/67-percent $KClO_4$ or 41-percent TiH_x/59-percent $KClO_4$ by weight, were used in the igniters illustrated. Two particle sizes of the TiH_x, designated as coarse and fine, were also used in the pyrotechnic blend. The coarse material had a mean diameter of 8 microns and the fine one of 3 microns. The igniters were hot-wire ignited using a 1-ohm bridge and a firing current of 3.5 A.

The experimental configuration used to record the high-speed photographs of the energetic materials and components is shown in Figure 1. The beam from the copper vapor laser is compressed by a spherical-cylindrical lens combination to form a "laser sheet" that passes across the top of the component. The laser operates at a pulse repetition rate of 6 kHz, with an average power of approximately 30 W. The short pulsewidth of the laser, about 30 ns,

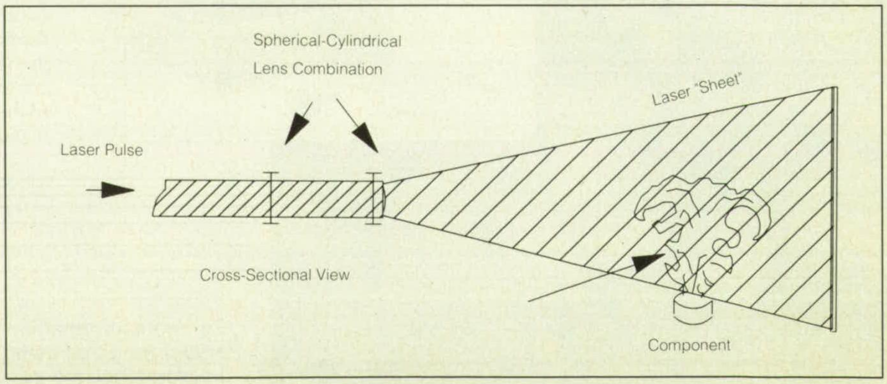


Figure 1. **Copper Vapor Laser Sheet Lighting** for high-speed photography of pyrotechnic components.

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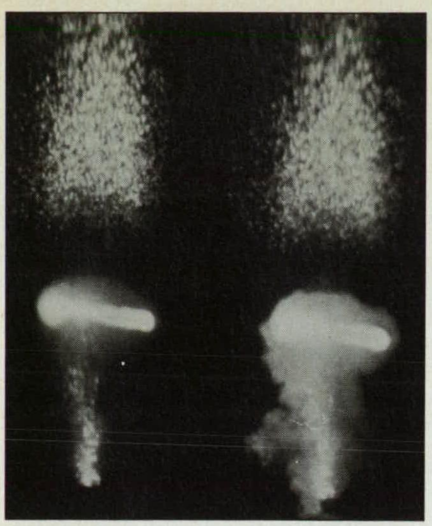


Figure 2. Frame 7 from a **Laser-Illuminated High-Speed Film** of coarse-particle $TiH_x/KClO_4$.

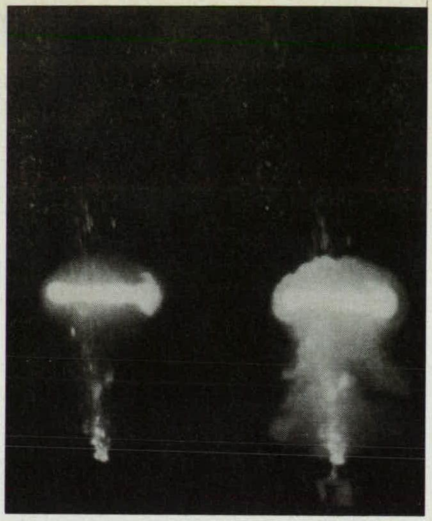


Figure 3. Frame 7 from a **Laser-Illuminated High-Speed Film** of fine-particle $TiH_x/KClO_4$.

provides illumination for unique stop-action photographs. The height of the laser sheet is approximately 10 in., and the camera is positioned to view the component normal to the plane of the laser sheet.

The sheet lighting is a particularly useful technique for filming functioning thermal battery igniters. As the igniter functions, the smoke, particulates, and sometimes the closure disk pass vertically through the laser sheet. Light scattering from the sheet is recorded by the camera, and details the internal structure of the flame. The high-speed camera was equipped with a rotating prism designed to record two images per frame of film. Since there is only one trigger pulse to the laser for each frame of film, each frame records both a laser-illuminated image and a nonlaser-illuminated image. This permits a ready comparison of each individual igniter, and illustrates the extra information recorded by using the laser. This additional information would be lost if only the visible light generated by the igniter were used to record the details of the igniter function.

Many different thermal battery igniters were filmed using copper vapor laser illumination. Perhaps the most striking of these results compares identical igniters, with the only change being the particle size of the fuel in the $TiH_x/KClO_4$ pyrotechnic blend. Mound currently is the only source for these blends. Figures 2 and 3 are representative frames from the high-speed film of two igniters. Frame no. 7, selected from each high-speed film, represents an elapsed time of 1.2 ms after closure-disk rupture. Figure 2 shows the output of the igniter loaded with the coarse TiH_x fuel, and Figure 3 the same type of igniter loaded with the fine TiH_x fuel.

The results show a significant difference between the two materials. The coarse material exhibits a large number of hot particles that continue to burn for a relatively long period of time (more than 3 ms after closure-disk rupture). The igniter loaded with the fine particle mix, however, shows mostly burned material and essentially no hot particles. This indicates that most of the fuel was consumed prior to closure-disk rupture. The burn time for this igniter is only about 1 ms.

These igniters were designed to ignite the heat pellets in a thermal battery, and the mechanism by which the ignition of the pellets takes place is of fundamental importance. A detailed frame-by-frame analysis of films that record pellet ignition in a model thermal battery indicates that they may be ignited by the hot gas produced by the igniter instead of by hot particles. In order to more accurately evaluate this hypothesis, photographic experiments at higher resolution using appropriate igniters are planned.

The technique of laser-illuminated high-speed photography can yield considerable information on how pyrotechnic devices function. Details of the igniter function, including particle velocity, quantity of hot particles produced, function time, extent of combustion prior to closure-disk rupture, and the effect of closure-disk thickness have been recorded. This technique has also been applied to other energetic materials including TiB, thermites, and laser-ignited devices.

This work was done by Dr. Larry R. Dosser, **EG&G Mound Applied Technologies**, *Mound Laser & Photonics Center. EG&G Mound Applied Technologies is operated for the U.S. Department of Energy under contract no. DE-AC04-88DP43495. Inquiries should be directed to Dr. Dosser, at PO Box 3000, Miamisburg, OH; (513) 865-4046, FAX (513) 865-3680, E-mail: DOSSLR@DOE-MD.GOV (Internet).*

Trace Analysis for Samples of Atomic Dimensions

Laser ionization allows trace analysis of surfaces and micron-sized particles.

Argonne National Laboratory, Argonne, Illinois

There is a class of important analytical problems that requires both efficient sample usage and the ability to identify impurity atoms at concentrations smaller than one part per billion. One example is in the area of trace surface analysis. Typified by the increasingly stringent requirements for analytical measurements of electronic materials, this type of measurement requires both high discrimination, to allow parts-per-billion measurement, and high useful yield, since only a few trace atoms may be present in the near-surface region.

Particulate analysis also requires this combination of discrimination and useful yield. In many ways, particulate analysis can be considered a subset of a broad area of problems associated with high-lateral-resolution imaging of the chemical content of complex, inhomogeneous samples. This set of problems may be grouped under the umbrella of ultratrace analysis; that is, problems where the analyte of interest is located in a sample of limited size and is at low concentration.

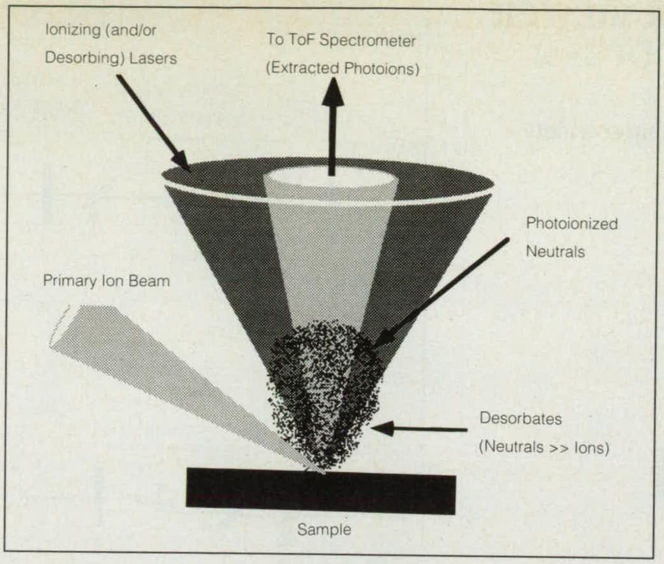
In the past several years, post-ionization has played a key role in addressing this industrially important class of analytical problems. The key is to use an efficient post-ionization method and a discriminative mass analysis technique. The line diagram shows the ionization and extraction region of an instrument developed at Argonne National Laboratory and dubbed SARISA (Surface Analysis by Resonant Ionization of Sputtered Atoms), which has been used successfully to address this problem area.

The instrument is capable of trace surface analysis with monolayer depth to resolution and submicrometer lateral resolution. It uses lasers tuned to resonantly ionize sputtered or laser-ablated neutral atoms, allowing superb selectivity and excellent useful yield (atoms detected/atoms removed from sample). A microscope employing reflected-light optics is built in, permitting samples to be viewed with submicrometer resolution and allowing introduction of focused UV light for laser ablation of samples a few micrometers across. Secondary neutrals can also be sputtered by using an ion gun with a 30° incident angle. Lasers tuned to resonant frequencies ionize neutral atoms immediately above the sample surface. The resulting ions are extracted normal to the surface and passed through a reflectron-type time-of-flight mass spectrometer's 4-m flight path, capable of a mass resolution ($\Delta M/M$) of 10^4 (not shown in the figure).

Testing of the recently completed instrument has demonstrated submicrometer imaging, laser ablation on submicrometer spots, and high mass resolution. Planned improvements to the instrument include installation of tunable solid-state lasers for resonance ionization and a femtosecond-pulse-length laser for saturated, nonresonant ionization of elements for which isobaric interferences are not a problem.

This system has also been used successfully to analyze naturally occurring samples, where two important problems arise for conventional techniques: the presence of isobaric interferences (between Zr and Mo, for example), and ineffective ionization of some elements, such as siderophiles. The use of laser ionization obviates both of these problems. Gas-

The ionization and extraction region of **SARISA** for trace surface analysis.



phase ionization of sputtered atoms is extremely discriminative, eliminating most isobaric detection problems. Moreover, the high useful yield of SARISA is not compromised by changes in the ionization potential of the analyte of interest. Current limitations, such as the low repetition rates of today's lasers and the need to tune them for each element, are being addressed in an upgrade now taking place.

This work was done by Michael J. Pellin, Wallis F. Calaway, Keith R. Lykke, and Dieter M. Gruen for **Argonne National Laboratory**, *supported by the U.S. Department of Energy, Basic Energy Sciences — Materials Sciences (contract W-31-109-ENG-38). For further information,* ***write in 20*** *on the Reader Information Request Card.*

For information regarding licensing, contact Robert J. Marchick, GC-42, 1000 Independence Ave. S.W., Washington, DC 20585; (202) 586-4792.

A Completely Solid-State Tunable Ti:Sapphire Laser System

A compact, flexible system is adaptable for lidar and atmospheric spectroscopy.

Goddard Space Flight Center, Greenbelt, Maryland

A compact, completely solid-state tunable pulsed laser system that is passively cooled has been developed for potential employment in aircraft and sounding-rocket lidar experiments. The Ti:sapphire (Ti^{3+}:Al_2O_3)-based laser system, depicted in Figure 1, is pumped with a frequency-doubled diode-pumped Nd:YAG (Nd^{3+}:$Y_3Al_5O_{12}$) laser. The system's tuning range, from 750-800 nm, was chosen to overlap the 766.49-nm absorption line of potassium; in-situ measurements of this line will enable scientists to study upper-atmosphere dynamics. The tuning range can easily be extended to bands between 650-950 nm in order to study other atmospheric constituents. Therefore, this rugged, self-contained system is extremely flexible and provides pulsed output at specific frequencies with low input-power requirements.

The pump portion of the system is a Q-switched Nd:YAG laser that is pumped with two three-bar stacks of GaAlAs lasers. The SDL-3230 series laser diodes provide a 200-µs pulse of 810-nm pump radiation at a maximum repetition rate of 100 Hz. They are conductively cooled through the base of the laser mount. Thermoelectric coolers (TECs) are not employed in the system to keep the overall power consumption to a minimum, allowing for potential battery-powered operation. This cooling scheme has proven effective in keeping the pump radiation frequency-stable over time periods comparable to those for possible missions.

A cylindrical lens with a 300-µm radius is used to couple the diode pump radiation into the Brewster-cut Nd:YAG half-rod, which is AR-coated at 810 nm on the pump face and HR-coated for 1064 nm on the back side. This coupling scheme matches the pump radiation to the lowest-order mode of the laser, thus forcing it to run in a single spatial mode.

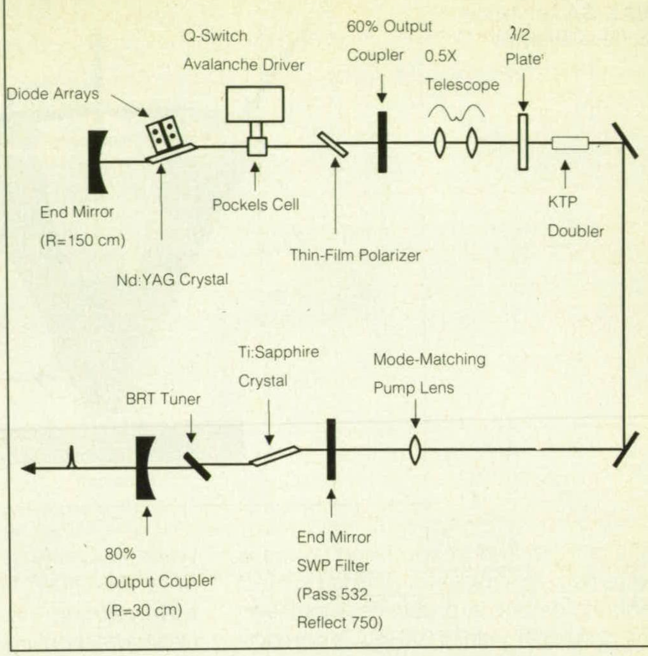


Figure 1. Breadboard configuration of a **Completely Solid-State Tunable Ti:Sappphire Laser System.**

A lithium niobate ($LiNbO_3$) Pockels cell in tandem with a thin-film polarizer are used to Q-switch the laser. The resulting laser pulses, coupled out of the cavity through a 60-percent reflector, have a pulsewidth of less than 20 ns in a TEM_{00} spatial mode. The laser exhibits an optical-to-optical efficiency of 4.5 percent, yielding 2-mJ pulses while pumped with diodes operating at 50 A of input current.

The Nd:YAG pump radiation is frequency-doubled from 1064 to 532 nm, to match the pump bands of Ti:sapphire. Potassium titanyl phosphate (KTP), a nonlinear type II doubling crystal, was chosen because its nonlinear coefficient is 15 times larger than potassium dihydrogen phosphate, and it performs well at low powers. A 1064-nm half-wave plate rotates the pump radiation's polarization to maximize the doubling efficiency and produce frequency-doubled radiation in the correct polarization orientation to pump the Ti:sapphire. The fundamental radiation is telescoped down to achieve higher intensities while maintaining a planar wavefront for best phase matching. This configuration yields close to 60 percent frequency doubling of the TEM_{00} fundamental radiation.

To lower the threshold of the Ti:sapphire laser, the frequency-doubled Nd:YAG radiation is focused into the Brewster-cut Ti:sapphire crystal with a lens chosen to minimize the spot size of the pump beam in the crystal without exceeding its damage threshold. This focused radiation is coupled into the laser cavity through a short-wavepass dichroic beamsplitter, coated to transmit at 532 nm and reflect radiation centered at 750 nm. A birefringent tuner is employed to scan the Ti:sapphire wavelength continuously from 750-800 nm; this three-plate tuning element narrows the laser radiation to a bandwidth of approximately 2 GHz and limits the tuning curve of the laser, depicted in Figure 2, to its free spectral range. The resulting Ti:sapphire radiation is coupled out of the cavity through an 80-percent output coupler. The radiation has a peak pulse energy of 200 μJ in a 16-ns gain-switched pulse, while pumped with 0.95 mJ of doubled Nd:YAG radiation of the same pulsewidth. As can be seen from the plot in Figure 3, the laser has an overall slope efficiency of 35.5 percent and a threshold of 0.29 mJ of 532-nm pump energy.

Overall, the system exhibits an optical-to-optical efficiency of 0.5 percent from the pump diodes to the Ti:sapphire output. Close agreement between experimental results and theoretical modeling of the system have also been demonstrated. In the laser-rate equations both passive and active losses, such as dispersive and Q-switch fall time respectively, were considered. Such a firm understanding of the laser's behavior supports the ability to scale the system to meet the requirements for specific missions. Therefore this compact, highly flexible system could be adapted for use by scientists for future studies of atmospheric chemistry and dynamics.

This work was done by David V. Guerra and D. Barry Coyle of the National Research Council and Danny J. Krebs for **Goddard Space Flight Center**. *Inquiries concerning the adaptation of this system for specific needs or regarding the techniques of design and assembly should be directed to Dr. Krebs at NASA/GSFC, Greenbelt, MD 20771; (301) 286-7714. Refer to GSC-XXXX.*

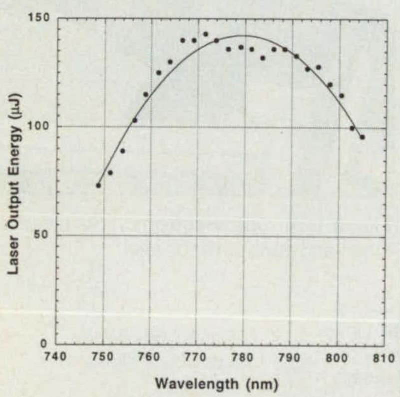


Figure 2. **Tuning Curve** with current mirror set.

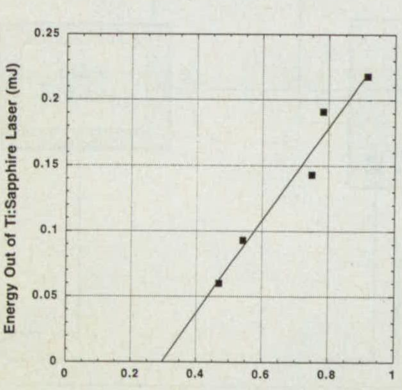


Figure 3. Ti:sapphire **Pulsed Output** vs, pump energy.

Optoelectronic Tool Measures Steps and Gaps Between Tiles

Tedium and subjectivity of the measurement process are reduced.

John F. Kennedy Space Center, Florida

An optoelectronic tool measures gaps between tiles and steps between the faces of the tiles (see Figure 1). The tool eliminates the need for difficult, tedious, time-consuming, and error-prone manual measurements with feeler gauges and trammel tools. This tool automates measurements of steps and gaps to within 0.006 in. (0.15 mm) versus 0.010 in. (0.25 mm) for manual methods. The tool records data automatically, whereas technicians using manual methods spend about 70 percent of their time recording and documenting data. The tool was developed for inspecting thermal-insulation tiles on the Space Shuttle but should be readily adaptable to inspection of any other settings where steps and gaps are critical.

A technician rests the tool lightly on two or more adjacent tiles to be inspected. Four legs with padded feet position four laser scanners and a video camera at a fixed distance from the surface of the tile. The lasers scan, in pairs, the surface along a thin line while the reflected scanning beams are captured by the camera. The scanned lines appear on video monitors as a displaced line at a step and hooked lines at a gap.

The laser scanners, camera, and video monitor (see Figure 2), which the operator uses to align the tool with the tiles at the beginning of each measurement sequence, are connected by a cable to a belt-pack control box worn by the technician. The computer leads the operator through measurements with menus and questions on its screen. At the end of a measurement session, upon operator request the computer prints out a report.

This work was done by Dick Davis of **Kennedy Space Center**, *and Rebecca Welling, Ed Huber, and Rick Williams of Lockheed Missiles & Space Operations Co. For further information,* ***write in 96*** *on the Reader Request Card. KSC-11583.*

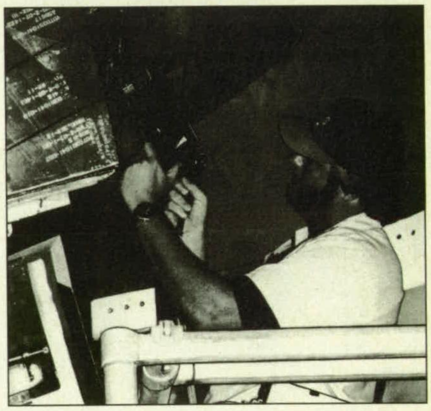


Figure 1. An **Optoelectronic Tool** measures steps and gaps between tiles.

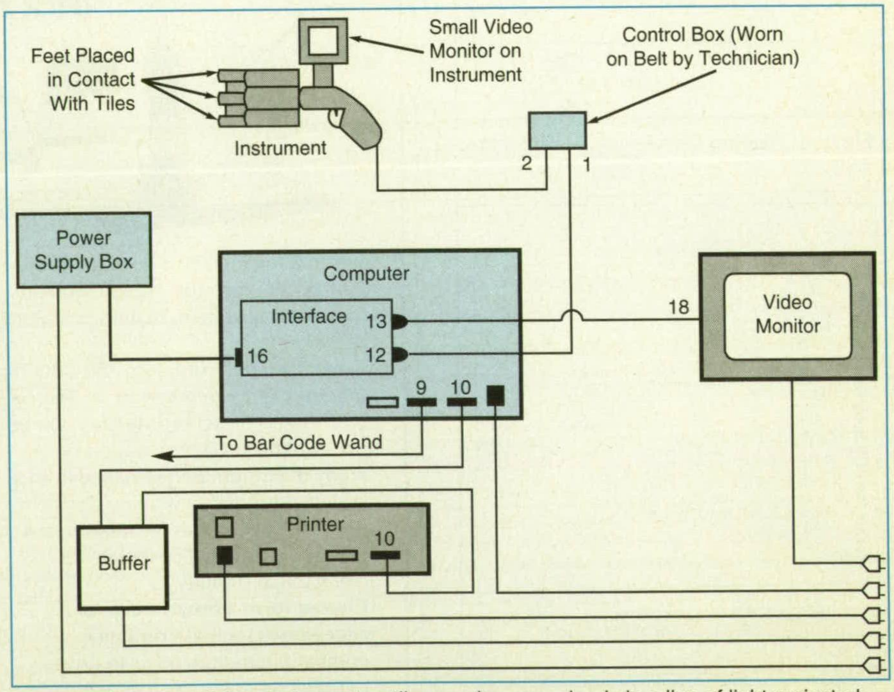


Figure 2. A **Step and Gap** between two tiles can be seen clearly in a line of light projected onto the tiles by a laser and associated optics. The line is viewed by a video camera, and the video image is processed to extract the dimensions of the step and gap.

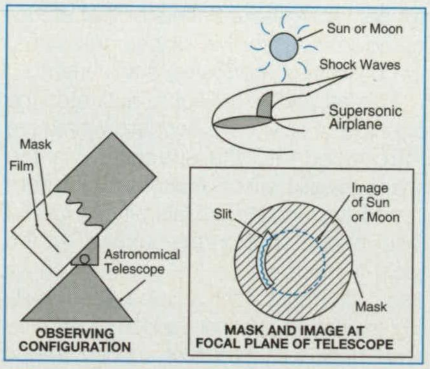
Schlieren Imaging of an Aircraft in Flight

Some details of compressible flow can be made visible.

Langley Research Center, Hampton, Virginia

A technique for making schlieren images of airplanes and missiles in supersonic flight has been devised to help researchers understand the physics of compressible aerodynamic flows about the complicated aircraft shapes. The technique could be used to study far-field sonic booms, for example. The data obtained from the schlieren images could be useful in optimizing the designs of prototype aircraft.

The technique incorporates elements of focusing schlieren photography, astronomical photography, and streak photography. A telescope is used to track the Sun during the day or the Moon during the night, so that the image of the Sun or Moon is made stationary in the focal plane of the telescope. An opaque mask that contains a narrow, curved slit is positioned in the focal plane of the telescope so that it blocks all except a thin edge portion of the Sun or Moon image along with a narrow adjacent portion of the sky image (see figure). The light that passes through the slit defines a curved gridline in the manner of a focusing schlieren system. An aircraft is flown through the field of view crossing this strip of light. Due to the large distance to the aircraft, the cutoff-mask-focus location and air-



Using the Sun or Moon as a source of light, this apparatus forms a schlieren image that reveals gradients of density in the air flowing around the supersonic airplane.

craft-image-focus location are very close together. A relay optical system is used to reimage and separate physically the two locations, and the aircraft image is sharply focused onto a second focal plane.

A strip of film is moved across the second focal plane, approximately following the motion of the aircraft. When the aircraft flies through the narrow, curved field of view defined by the slit, its schlieren image is formed on the film. The schlieren image reveals gradients of density perpendicular to the curved sliver of light. The length of the field of view that can be imaged is limited only by the length of the exposed film strip. The apparatus can be characterized as functioning like a streak camera that is sensitive to schlieren effects.

If the movement of the film does not track the motion of the aircraft accurately, the image on the film is distorted, but analog and/or digital postprocessing of the image can correct for the distortion. Instead of using film, one could record the image electronically by time-delay integration, in which the moving image is tracked by scanning sequential rows of pixels in a charge-coupled device or other imaging array of photodetectors. Although the initial cost of equipment is greater, this approach offers the advantage of rapid, direct electronic processing and postprocessing.

This work was done by Leonard M. Weinstein of **Langley Research Center**. *No further documentation is available.*

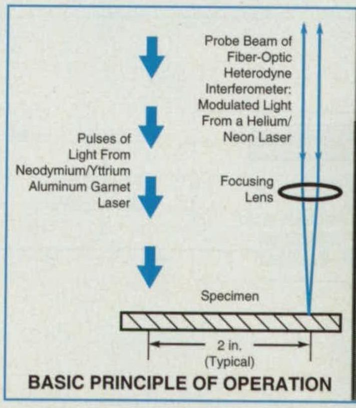
Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Langley Research Center [see page 8]. Refer to LAR-15053.

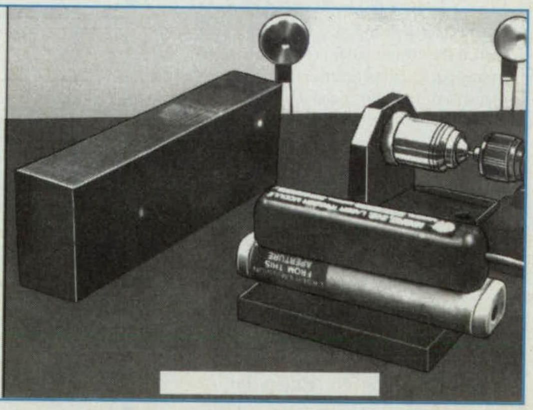
Noncontact Acousto-Ultrasonic Testing With Laser Beams

Laser beams are used to excite and detect acoustic waves in specimens.

Lewis Research Center, Cleveland, Ohio

Experiments have demonstrated the feasibility of a laser/acousto-ultrasonic technique for the nondestructive testing of materials. As in older acousto-ultrasonic techniques that involve direct or indirect contact between specimens and mechanical (e.g., piezoelectric) transducers, the objective is to identify defects in specimens and/or evaluate the mechanical properties of specimen materials by measuring changes in acoustic waves that propagate through the specimens. The need for contact in the older techniques entails several disadvantages, including the need for coupling liquids or fixtures that can harm specimens; dis-





Heating by Laser Pulses generates acoustic waves, which are detected interferometrically.

tortion of acoustic signals in the liquids, fixtures, and acoustic transducers; and further distortion of signals in unwanted couplings among all components.

The laser/acousto-ultrasonic technique entails no mechanical contact between specimens and the testing apparatus, and, therefore, none of these disadvantages. In addition, the testing apparatus can be located at relatively large distances (meters) from specimens: this makes it possible to test specimens that are too hot for contact measurements or that are located in inaccessible places, vacuums, or hostile (e.g., corrosive) environments.

The left part of the figure illustrates the principle of operation. Acoustic waves are introduced into the specimen via the thermoelastic effect: Pulses of light from a neodymium/yttrium aluminum garnet laser heat a spot on the surface. As the local temperature in the spot alternately rises, then falls after a pulse, the resulting expansion and contraction of the material in the spot generates acoustic waves that propagate out from the spot. The acoustic waves cause displacement of the surface. The displacement is measured at another spot by use of a heterodyne laser interferometer, the probe beam of which is aimed at that other spot.

The right part of the figure shows the setup for one of the experiments, in which acoustic waves were generated and detected on one side of a specimen block of graphite/epoxy laminate. In similar experiments, waves were generated on one side and detected on the other side of a brass plate and an aluminum plate, respectively. In another experiment, the interferometric part of the apparatus was used alone (that is, without the pulsed heating laser) to measure the acoustic signal transmitted along the surface of a thick aluminum block when a glass capillary was broken on the surface. In yet another experiment, the interferometric part was used to detect 5-MHz ultrasound propagating through a thick aluminum block. In all cases, the interferometric part of the apparatus captured waveforms that agreed well with theoretical predictions, while conventional piezoelectric transducers did not.

This work was done by Robert D. Huber and Robert E. Green, Jr., of the Johns Hopkins University for **Lewis Research Center**. *For further information* ***write in 6*** *on the Reader Request Card. LEW-15524*

Optical-Fiber Leak Detector

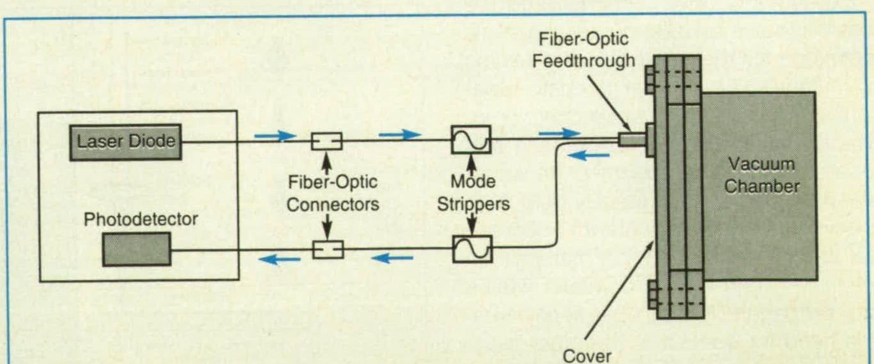
Pressure-induced microbending would increase the attenuation of light passing through fiber.

Marshall Space Flight Center, Alabama

A proposed optical-fiber sensor would detect small changes in pressure in an elastomeric O-ring or similar pressure seal. Unexpected changes may indicate deterioration of the seal and thus could be interpreted as indications of incipient failure.

According to the concept, a length of optical fiber would be embedded in the seal. A light-emitting diode would illuminate one end of the fiber; a photodetector would measure the intensity of the light emerging from the other end. Pressure-induced changes in the seal would bend the fiber slightly, altering the microbending-induced loss of light from the fiber and thereby altering the intensity of light at the photodetector. The change in intensity would be approximately proportional to the change in pressure.

The concept was demonstrated with a commercial communication-grade, multimode optical fiber. A laser diode, driven by a current source and with a thermoelectric controller to maintain a stable inten-



The **Output of the Photodetector Varied With Pressure** in the vacuum chamber, demonstrating the feasibility of the sensor concept.

sity, was connected to the fiber through commercial connectors (see figure). A mode stripper removed high-order light-propagation modes from the cladding on the fiber. The fiber entered a vacuum chamber, where it was arrayed in a spiral, then continued back out of the chamber to another mode stripper. The output end of the fiber faced a photodetector.

Even though the fiber was designed to minimize microbending loss, the output of the photodetector registered a significant nonlinear response to changing pressure. In a fiber formulated expressly for this use, the response to a change of pressure and to acoustic waves generated by air flowing through a leak could be made large and linear. The linearity, sensitivity, and dynamic range could also be improved by changing the pitch of the spiral or by adding more mode strippers or a mode scrambler.

This work was done by Gary L. Workman and Susan E. Kosten of the University of Alabama in Huntsville for **Marshall Space Flight Center**. *For further information,* ***write in 36*** *on the Reader Request Card.*

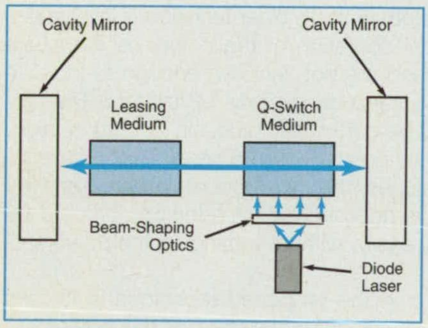
Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 8]. Refer to MFS-26242.

Optically Driven Q-Switches for Lasers

Energy efficiencies may exceed those of electrically driven Q-switches.

NASA's Jet Propulsion Laboratory, Pasadena, California

Optically driven Q-switches for pulsed lasers have been proposed. The new Q-switches would take the place of acousto-optical, magneto-optical, and electro-optical switches, which typically include high-electrical-power switching circuitry. The optical switching beams of the proposed Q-switches would most likely be generated in pulsed diode lasers or light-emitting diodes, the outputs of which can be amplitude-modulated easily by direct modulation of relatively small input currents. The electrical-energy efficiencies of the proposed Q-switches are expected to be 50 to 90 percent greater than those of the prior Q-switches.



The **Q-Switch Medium** would be illuminated by a pulsed diode laser.

Typically, the Q-switch medium would be incorporated into the laser cavity along with the lasing medium. The pulsed Q-switching beam of light could be injected laterally into the Q-switch medium as shown in the figure, or else longitudinally. The Q-switch medium could be a solid, liquid, or gas. One of the main requirements upon this material is that it be more than 99-percent transparent at the laser wavelength in one of its switching states: this is necessary to make the laser as efficient as possible.

The proposed Q-switches, in combination with the lasers into which they would be incorporated, can be classified into several types. In a device of one type, the wavelength of the diode laser would be matched to the absorption band of the Q-switch medium, such that the light from the diode laser would raise the medium to an excited state in which the wavelength of a transition to another excited state equals the wavelength of the laser pulse that is to be generated. When periodically illuminated by the diode laser, the Q-switch medium would thus act as a periodic intracavity shutter in the form of a laser-beam absorber.

A variant of the absorbing-medium type of Q-switch would be suitable for use with a quasi-three-level solid-state laser. In a laser of this type, the lasing medium should be kept short or cooled to minimize reabsorption of laser light. The Q-switch medium would be of the same material as that of the lasing medium, but it would be longer.

An optically activated Q-switch of a different type could be based on a bistable or optically nonlinear medium. For example, the medium could be switchable, by

irradiation at a specific Q-switching wavelength, from total internal reflection to transparency at the laser wavelength. The Q-switch would include a quartz crystal oscillator driven at its resonant frequency by light from a diode laser, typically at a wavelength of 800 or 1,300 nm. In this case, the pulse-repetition frequency would have to be fixed at the resonant frequency of the crystal.

This work was done by Hamid Hemmati of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 13*** *on the Reader Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, NASA Resident Office-JPL [see page 8]. Refer to NPO-18470.

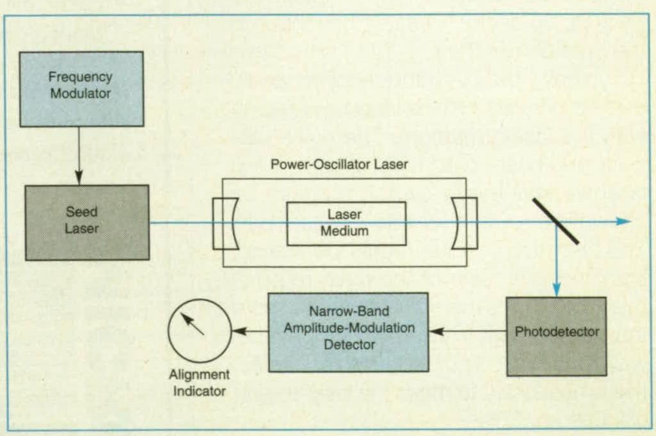
Sensitive Technique for Detecting Alignment of Seed Laser

Frequency response near resonance is measured.

Langley Research Center, Hampton, Virginia

An improved technique for detection and quantification of alignment of an injection-seeding laser with the associated power-oscillator laser has been proposed. Heretofore, such alignment has been detected and quantified via measurements of laser-pulse-evolution times and/or measurements of spectral purity of laser output. Both of these older techniques involve disadvantages: they entail operation of the power oscillator, are difficult to implement, and are not sensitive enough to indicate misalignment when spectral purity exceeds 98 percent. The proposed technique would be particularly useful in indicating alignment at a spectral purity greater than 98 percent because, contrary to the older techniques, this one becomes more sensitive as perfect alignment is approached. In addition, it could be implemented relatively easily, without turning on the power-oscillator laser.

The basic approach in the proposed technique is to take advantage of the resonant characteristics of the power oscillator, which has a structure like that of an etalon with curved mirrors (see figure). The transmission and reflection characteristics of such a structure depend on both the frequency and the alignment of the beam from the seed laser: If the alignment is incorrect, the seed laser beam cannot be well coupled to the resonator; consequently, the transmission and reflection char-



The **Amplitude Modulation** of the photodetector would increase as the alignment between the seed and power-oscillator lasers became more nearly perfect.

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acteristics tend to be nearly independent of the deviation of the frequency of the seed laser beam from the resonant frequency. If the alignment is correct, the seed laser beam can be well coupled to the resonator, provided that the beam has the resonant frequency; consequently, in this case, the transmission and reflection characteristics depend more sharply on the deviation of the frequency from the resonant value.

Thus, in the proposed technique, one would frequency-modulate the seed laser to sweep the seed-laser frequency repeatedly through the resonant value while measuring the transmission of the seed laser beam through (or the reflection of this beam from) the power-oscillator resonator structure. This frequency modulation would give rise to amplitude modulation of the measured transmission or reflection. The depth of this modulation would increase as correct alignment was approached, causing the reflection or transmission to vary more sharply with frequency.

One of the advantages of this technique would arise from the fact that it involves the measurement of a sinusoidally varying voltage: This is relatively easy to do, and one could take advantage of narrow-band detection methods to increase the signal-to-noise ratio, thereby making the technique even more sensitive. In a refinement of the technique, one could measure the power of the seed laser beam and compute a ratio between the depth of modulation and this power to obtain a measure of alignment independent of this power. In yet another refinement, one could use the amplitude-modulation signal as feedback in an automatic alignment control system.

This work was done by Norman P. Barnes of **Langley Research Center.** *No further documentation is available.*

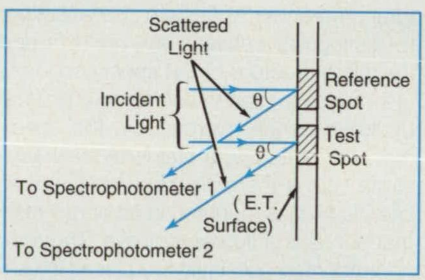
Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Langley Research Center [see page 8]. Refer to LAR-14867.

Remote Measurement of Thickness of Ice

The buildup of ice on surfaces would be measured optoelectronically.

Langley Research Center, Hampton, Virginia

A potential problem in the Space Shuttle arises from the possibility of ice buildup on the surface of the external tank while the spacecraft is mounted on its launch pad. When the tank is filled with liquid oxygen and liquid hydrogen, there is a very large thermal gradient across its insulation. If there is a weakness or defect in the insulation, cold spots can develop on it, leading to condensation and/or freezing of water vapor. At present, frost or frost on clear ice on the tank can be detected by thermal imaging coupled with conventional television. However, there is no technique currently available for detecting clear ice alone; nor are there any techniques for measuring thickness of frost, frost on ice, or clear ice. Consequently, a technique for remote measurement of the thickness of an ice layer on a surface has been proposed.



Radiation in Three Near-Infrared Wavelength Bands would be scattered from both the test spot and a nearby reference spot, and the ratios of their intensities would be compared to determine the thickness of ice.

In the case of the external tank of the Space Shuttle, the surface is uniformly flooded with natural or simulated sunlight before launch. Consequently, there is enough electromagnetic radiation, in the near and mid-infrared spectral ranges, incident on the surface at all times. The proposed technique involves the selection of three neighboring near-infrared wavelength bands: one ($\lambda_1 \pm$ 100 Å) off resonance in ice and two (λ_2 ± 100 Å and λ_3 ± 100 Å) on resonance in ice. The ratios of the intensities of radiation in the three preselected near-infrared wavelength bands scattered from a test spot and from a neighboring reference spot on the surface of the tank would be compared. The design and calibration of the ice-detecting system would incorporate a comparison of the ratios for a test spot with a dry surface and then at various known thicknesses of ice.

As shown schematically in the figure, two spectrophotometers would receive radiation scattered from selected areas on the surface. Spectrophotometer 1 would receive radiation scattered from the reference area only. Spectrophotometer 2 would be aimed at test spots on suspect areas on the surface. Each photometer would be equipped with filters to accept radiation in all three bands simultaneously.

This technique would be applicable to all surfaces appropriately lit with adequate radiation in the three preselected bands. It should prove useful in a variety of applications, including aerospace applications, research, and measurement of ice thicknesses on aircraft surfaces.

This work was done by Jag J. Singh of **Langley Research Center**. *Further information may be found in NASA TM-102667 [N90-24584/TB], "Remote Measurement of Ice Thickness on the Shuttle External Tank Surface."*

Copies may be purchased [prepayment required] from the NASA Center for AeroSpace Information, Linthicum Heights, Maryland, Telephone No. (301) 621-0394. Rush orders may be placed for an extra fee by calling the same number. LAR-14636

Examining Thermally Sprayed Coats by Fluorescence Microscopy

True flaws can be distinguished from those induced by preparation of specimens.

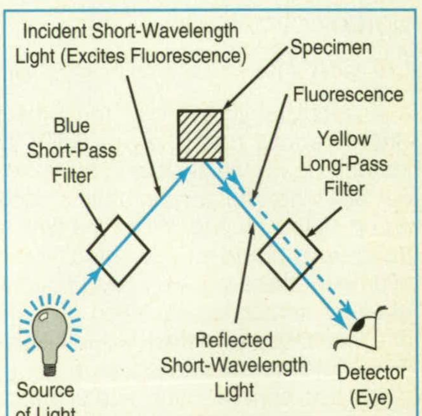
Lewis Research Center, Cleveland, Ohio

Fluorescence microscopy reveals debonding, porosity, cracks, and other flaws in specimens of thermally sprayed coating materials. Such flaws are often indistinguishable from void artifacts induced in the metallographic preparation of the specimens and viewed in ordinary light by bright-field microscopy. Fluorescence microscopy provides color-contrasting structural differences that help the examiner to distinguish between the artifacts and the microstructure of the specimen.

In a typical preparation for examination by fluorescence microscopy, the specimen (for example, a stainless-steel substrate with a thermally sprayed tungsten carbide coat) is mounted in an epoxy resin that contains a fluorescent dye. The resin and mounted specimen are placed in vacuum so that the mixture of resin and dye infiltrates the specimen. The specimen is then polished in stages with alumina, diamond, and finally colloidal silica.

The specimen is examined in a fluorescence microscope, where it is illuminated by light at a given wavelength and fluoresces at a greater wavelength (see figure). Both excitation and emission wavelengths are in the visible spectrum and depend on the dye chosen. Defects present in the original specimen appear as contrasting colored areas because they have been infiltrated with the dye; defects caused by metallographic processing of the infiltrated specimen appear simply as dark areas because they were introduced after infiltration.

The best viewing conditions are achieved by use of (1) a dye that is excited in the blue and fluoresces in the yellow and (2) a blue short-pass filter and yellow long-pass filter combination where the transmission overlap between filters allows approximately equal intensities of yellow and green to be viewed. Under these conditions, true original flaws appear as bright yellow areas against direct viewing of the specimen in green, while artifacts appear as black areas.



The **Specimen Is Illuminated**, and the dye that it contains fluoresces, emitting light at a different wavelength. The filters emphasize the contrast between the excitation light and the emission light. The specimen can be viewed directly or photographed on color film.

This work was done by Kenneth W. Street, Jr., of **Lewis Research Center** *and Todd A. Leonhardt of Sverdrup Technology, Inc. For further information* ***write in 4*** *on the Reader Request Card. LEW-15740*

Planar, High-Speed Metal-Si-Metal Photodetectors with Extended Infrared Response

Enhanced absorption in an ion-implanted damaged region extends the high-speed response of planar, CMOS-compatible photodetectors to wavelengths beyond 1 μm.

Center for High Technology Materials, University of New Mexico, Albuquerque, New Mexico, and Sandia National Laboratories, Albuquerque, New Mexico

The operating range of simple planar CMOS-compatible metal-semiconductor-metal (MSM) detectors based on Si has been extended to longer wavelengths. Absorption, both above and below silicon's E_g (bandgap), is enhanced by ion-implantation-induced defects in the high field region of the MSM (~ 1 μm below the surface) where carriers can be collected before trapping occurs. Initial results show an improvement of a factor of 3 at 860 nm (to 64 percent internal quantum efficiency) and a factor of 10 at 1.06 μm (to 23 percent). A dramatic improvement in the frequency response, particularly at the longer wavelengths, is also observed, since carriers are generated close to the surface.

Traditional electrical-based intracomputer interconnections are approaching fundamental speed and density limitations. Optical interconnections provide a potentially important approach for improved performance in board-to-board and chip-to-chip (including multichip module) applications, in optical disk storage and in local area networks. Although many possible architectures are under investigation, one aspect is common to all: eventually the optical interconnect must be integrated with the Si circuitry that dominates information processing. Most approaches to this problem investigate hybrid techniques in which III-V detectors are coupled to the Si circuit, requiring complex, highly precise, and delicate packaging and assembly that drive up production cost and drive down yield.

An integrated Si photodetector that was manufactured along with the Si circuitry would clearly be a more effective solution. The difficulty has been that the relatively weak optical absorption of Si over the wavelength range of interest (0.6 - 1.55 μm) dictates photodetector designs that are incompatible with standard VLSI manufacturing practice. The need for a deep vertical structure

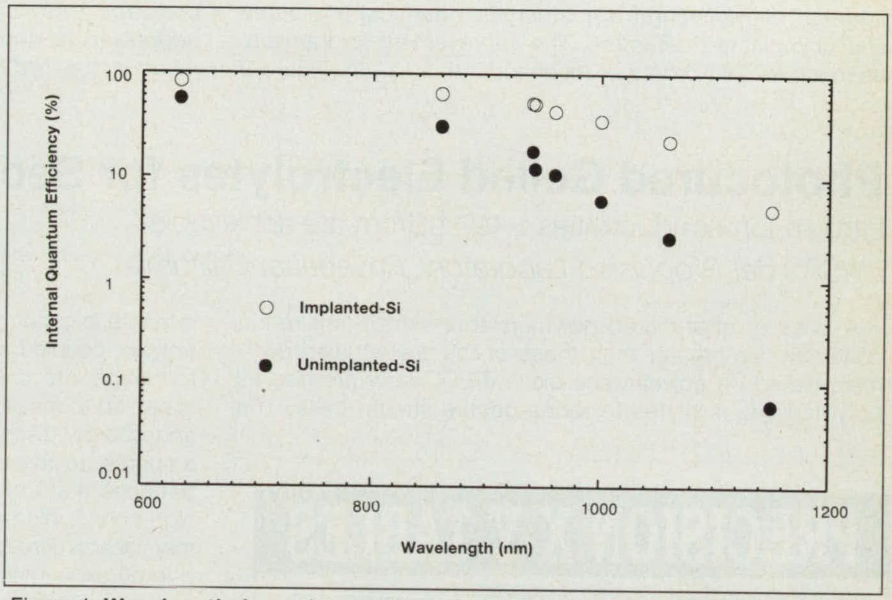
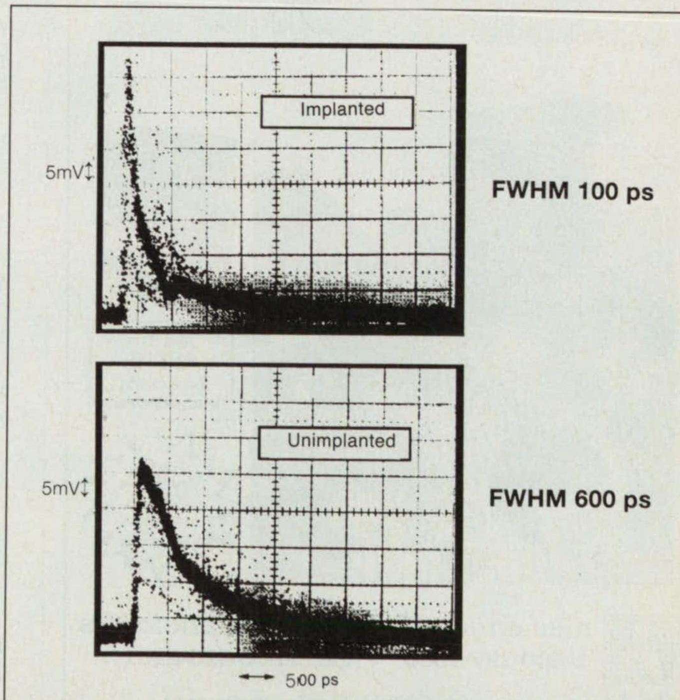


Figure 1. **Wavelength dependence** of the internal quantum efficiency for implanted and unimplanted Ni-Si-Ni photodetectors. The efficiency is improved by ~100 at 1.15 μm.

Figure 2. **Impulse response** for implanted and unimplanted detectors (4.5-μm gap, 10-V bias, 150-fs pulses at 760 nm).



makes such detectors' fabrication incompatible with the much shallower, top-side-only contact structure of VLSI circuitry and restricts operating speed.

MSM detectors based on III-V materials have been extensively explored, with particular emphasis on long-wavelength applications. The relatively small amount of work that has been reported for Si has emphasized short-wavelength and high-speed applications. Ion implantation creates a highly absorbing damaged layer within ~ 1 µm of the surface, in the high field region of an MSM device. For sub-gap energies, enhanced absorption as high as 10^3-10^4 cm^{-1} have been reported; no measurements are available for above-gap energies. The Center has used ion implantation to enhance both the long-wavelength quantum efficiency and speed of a conventional Si MSM photodetector, while retaining full compatibility with VLSI fabrication.

Figure 1 shows the measured quantum efficiency as a function of wavelength for otherwise identical implanted and unimplanted detectors. The improvement is dramatic, as much as two orders of magnitude at 1.15 µm. Figure 2 shows the impulse response for both implanted and unimplanted devices at 760 nm (excitation by a 150-fs, Ti:Al_2O_3 laser pulse). The implanted detector also shows a substantially improved dynamic response.

This work was done by Kristin Scott, Ashwani Sharma, and Prof. S.R.J. Brueck of the **Center for High Technology Materials (CHTM)**, *University of New Mexico, Albuquerque, New Mexico, in collaboration with Dr. D. R. Myers and Dr. J. C. Zolper of* **Sandia National Laboratories**, *Albuquerque, New Mexico.*

A patent has been applied for. Inquiries concerning detailed information and rights for the commercial use of this invention should be addressed to Prof. S. R. J. Brueck, CHTM, University of New Mexico, Albuquerque, NM 87131, or alternatively to the Alliance for Photonic Technology, 851 University Blvd. SE, Bldg. 1, Suite 200, Albuquerque, NM 87106-4339; (505) 272-7001. Inquiries regarding commercialization through licensing or CRADAs can also be addressed to Angelo Salamone, 10529 Research Rd. SE, Albuquerque, NM 87123-1380.

Photocured Gelled Electrolytes for Secondary Li Cells

Lithium-ion conductivities >10^{-4} S/cm are achievable.

NASA's Jet Propulsion Laboratory, Pasadena, California

A class of photocured polymers that exhibit lithium-ion conductivities greater than those of the well-studied polymers based on polyethylene oxide (PEO) show promise as polymeric electrolytes in rechargeable lithium cells. The increase in conductivity occasioned by the use of these electrolytes, coupled with the amenability of these electrolytes to formation into uniform thin (< 25 µm thick), wide films, is expected to result in cells with power densities >100 W•h/kg and charge/ discharge rates that exceed currents equal, in amperes, to the ampere-hour ratings. All-solid-state lithium batteries that contain these electrolytes could be used as high-power, high-rate rechargeable power sources in commercial and aerospace applications.

In an experiment, a liquid mixture to be photocured into a polymeric electrolyte was prepared as follows: About 6.0 g of equal weights of ethylene carbonate (EC) and propylene carbonate (PC) were weighed into a 40-mL glass beaker, to which 1.0 g of $LiN(CF_3SO_3)_2$ and 0.1 g of PEO of molecular weight 200,000 were added. After the mixture was stirred well, 2.9 g of a proprietary cycloaliphatic epoxide called ENVIBAR (for "environmental barrier") and a drop of a photoinitiator called "6990" were added. The resulting mixture was then stirred overnight, and the resulting homogeneous solution was uniformly brushed onto a Li foil kept in a polytetrafluoroethylene mold. The liquid film was about 400 µm thick.

The liquid film was cured by ultraviolet radiation for about 15 to 20 min. In the curing process, the photoinitiator absorbed ultraviolet radiation and dissociated into radical cations. The radical cations triggered the polymerization of the monomer, which, in turn, complexed with the organic liquid that contained the Li salt and formed a solid matrix. No toxic gases or vapors were evolved during and after formation of the cured film, which adhered tenaciously to the Li foil.

The cured film was subjected to a series of electrochemical measurements, including AC and DC measurements and long-term electrochemical studies. The bulk conductivity of the film at room temperature was found to be about 6 × 10^{-4} S/cm and to be stable for at least 72 h, after which the experiment was terminated.

This work was done by Ganesan Nagasubramanian of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 15*** *on the Reader Request Card. NPO-18958.*

Computer Programs

Pyrolaser Operating System

This software provides for control of and acquisition of data from an optical pyrometer.

Marshall Space Flight Center, Alabama

The PYROLASER software package is an operating system for the Pyrometer Instrument Company's Pyrolaser. There are six individual programs in the PYROLASER package: two main programs, two lower-level subprograms, and two programs that, although independent, function predominantly as macros. The package provides a quick and easy way to set up, control, and program a standard Pyrolaser. Temperature and emissivity measurements can be either collected as if the Pyrolaser were in the manual operating mode or displayed on real-time strip charts and stored in standard spreadsheet format for posttest analysis. A shell is supplied to allow macros, which are test-specific, to be added to the system easily.

The Pyrolaser Simple Operation program provides full on-screen remote-operation capabilities, thus enabling the user to operate the Pyrolaser from the computer just as it would be operated manually. The Pyrolaser Simple Operation program also enables the use of "quick starts," which facilitate the use of routines as setup macros for specific applications or tests. The specific procedures required for a test can be ordered in a sequence structure, and then the sequence structure can be started with a simple button in the cluster structure provided.

One quick-start macro is provided for continuous Pyrolaser operation. A subprogram, Display Continuous Pyr Data, is used to display and store the resulting output data. By use of this macro, the system is set up for continuous operation, and the subprogram is called to display the data in real time on strip charts. The data are stored simultaneously in a spreadsheet format. The resulting spreadsheet file can be opened in any one of a number of commercially available spreadsheet programs.

The Read Continuous Pyrometer program is provided as a continuously run subprogram for incorporation of the Pyrolaser software into a process-control or feedback-control scheme in a multicomponent system. The program requires the Pyrolaser to be set up by use of the Pyrometer String Transfer macro. It requires no inputs and provides temperature and emissivity as outputs. The Read Continuous Pyrometer program can be run continuously, and the data can be sampled as often or as seldom as updates of temperature and emissivity are required.

PYROLASER is written using the Labview software for use on Macintosh-series computers running System 6.0.3 or later, Sun Sparc-series computers running Open-Windows 3.0 or MIT's X Window System (X11R4 or X11R5), and IBM PC or compatible computers running Microsoft Windows 3.1 or later. Labview requires a minimum of 5 Mb of random-access memory (RAM) on a Macintosh, 24 Mb of RAM on a Sun, and 8 Mb of RAM on an IBM PC or compatible. The Labview software is a product of National Instruments (Austin, TX; 800-433-3488) and is not included with this program. The standard distribution medium for PYROLASER is a 3.5-in. (8.89-cm) 800K Macintosh-format diskette. It is also available on a 3.5-in. (8.89-cm) 720K MS-DOS-format diskette, a 3.5-in. (8.89-cm) diskette in UNIX tar format, and a 0.25-in. (6.35-mm) streaming-magnetic-tape cartridge in UNIX tar format. An electronic copy of the documentation in Macintosh WordPerfect version 2.0.4 format is included on the distribution medium. Printed documentation is included in the price of the program.

This program was written by Floyd E. Roberts III of **Marshall Space Flight Center**. *For further information,* ***write in 32*** *on the Reader Request Card. MFS-28819*

Template for Aiming an X-Ray Machine

A laser spotting beam is used for alignment.

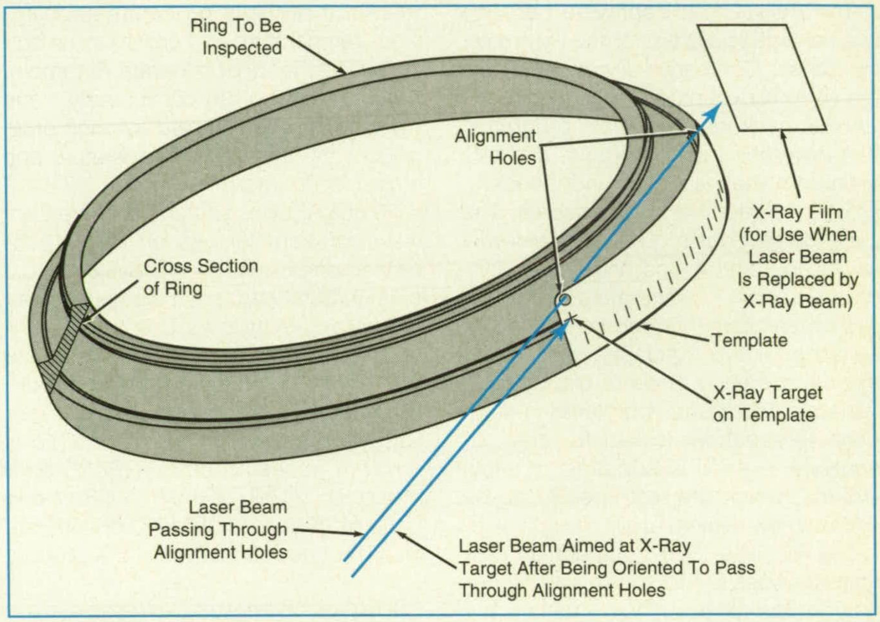
Marshall Space Flight Center, Alabama

A relatively inexpensive template helps in aligning an x-ray machine with a phenolic ring that is to be inspected for flaws. The phenolic ring in the original application is part of a rocket nozzle. The basic concept of the template should also be applicable to the x-ray inspection of other rings.

In the original application, the x-ray beam passes nearly tangentially through the ring on its way to the x-ray film. The thickness of material through which the beam passes determines the sensitivity to flaws. This thickness, in turn, depends on the direction of the x-ray beam and on where the beam strikes the ring. The template is designed to aid in adjusting both the angle of the beam and the location where the beam strikes the ring.

The template (see figure) is marked with degrees of angular distance around the ring to be inspected, and is wrapped around the ring. The template projects somewhat above the ring. Two alignment holes are drilled through the projecting portion of the template, separated by the angular distance that corresponds to the thickness of material through which the x-ray beam is meant to pass.

The x-ray machine is equipped with a laser that provides a visible spotting beam aligned with the axis of the x-ray beam. With the x-ray beam turned off and the laser beam turned on, the position and orientation of the x-ray machine are adjusted, relative to the ring and template, until the laser beam passes through both alignment holes in the template. Then maintaining the same orientation, the x-ray head is translated downward a short distance until the laser beam strikes an x-ray-target spot located below one of the alignment holes on the template. The use of the template decreases positioning time and error, providing consistent sensitivity for detection of flaws.



The X-Ray-Aiming Template contains alignment holes for adjusting the orientation, plus a target spot for adjusting the lateral position, of a laser spotting beam. (The laser spotting beam coincides with the x-ray beam, which is turned on later, after alignment has been completed.)

This work was done by W. J. Morphet of Thiokol Corp. for **Marshall Space Flight Center**. *No further documentation is available. MFS-28886.*

Correcting for Seed-Particle Lag in LV Measurements

A velocity-correction technique increases the accuracy of flow-velocity data.

Langley Research Center, Hampton, Virginia

The overall accuracy of measurements taken by a laser velocimeter (LV) is affected by many complex subsystems of the overall LV system. For example, sources of error are related to the optical, electronic, computer data-processing, and seeding subsystems. Seeding is the most difficult and the most often neglected aspect of laser velocimetry. Therefore, an experimental study was conducted to examine the errors in LV measurements attributable to lags of seed particles in subsonic and transonic flows.

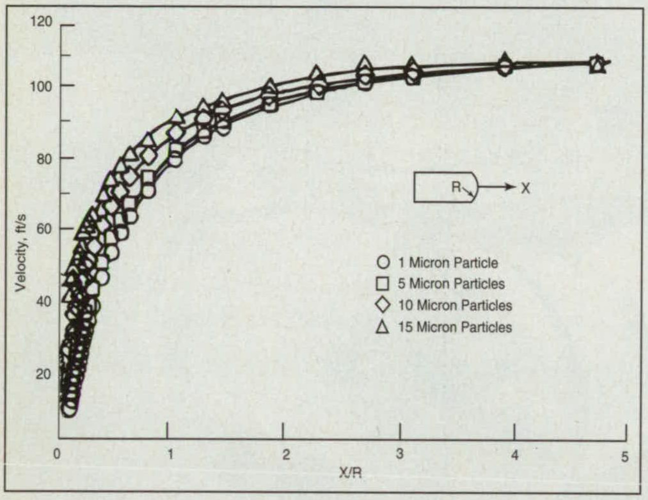
The LV measures flow velocities indirectly by measuring the speeds of small seed particles entrained in the flow. From an optical perspective, the system would operate more efficiently with large particles, but from an aerodynamical perspective, the particles should be small so that they "follow" or "track" the flow field. Although the small seed particles are assumed to track the flow velocity accurately, in reality the size and inertia of each particle is large enough to cause its velocity to lag behind the flow velocity, causing the measurements made by the LV to misrepresent the true flow velocities.

Two experiments were conducted to evaluate the effects of the sizes of seed particles on errors in LV measurements of mean flows. Both theoretical and conventional experimental methods were used to evaluate these errors. The

first experiment focused on the measurement of the decelerating stagnation streamline of a low-speed flow around a circular cylinder with a two-dimensional afterbody, shown in the figure. The second experiment was performed in a transonic flow and involved the measurement of the decelerating stagnation streamline of a hemisphere with a cylindrical afterbody. The data acquired in the experiment were used to evaluate the one-dimensional velocity-correction method for subsonic and transonic flows.

The lag in the responses of seed particles was confirmed to be a major source of errors in LV measurements of mean flow velocities. In slow flows, errors exceeding 5 percent were found for particle diameters greater than 5 μm. In transonic flows, errors up to 60 percent were found for particles with diameters of 2 to 3 μm and up to 30 percent for particles with diameters of 1 to 2 μm.

A three-dimensional mathematical model was developed to determine the magnitudes of errors caused by the lags in the responses of seed particles. This model is based on a simplified particle-force-balance model and an empirical coefficient-of-drag



Velocities of Seed Particles along a decelerating stagnation streamline depend on the sizes of the particles.

model for spherical bodies. A one-dimensional version of this model was shown to be successful in correcting the velocity measurements in both the subsonic and transonic flow regimes. Corrections to laser-velocimetry data taken on the stagnation streamline of the circular cylinder and the hemisphere-cylinder models demonstrated the capability to reduce errors by a factor of 3 or more.

From these experiments, it was concluded that mean-quantity LV measurements are subject to large errors directly attributable to the sizes of the particles. The predictions of particle-response theory showed good agreement with the experimental results, indicating that the velocity-error-correction technique used in this study is viable for the increasing accuracy of laser velocimetry measurements. The technique is simple and should be useful in any research facility in which flow velocities are measured.

This work was done by Gregory S. Jones and Luther R. Gartrell of **Langley Research Center** *and Derek Y. Kamemoto of George Washington University. Further information may be found in AIAA paper 90A-26959, "An Investigation of the Effects of Seeding in Laser Velocimeter Systems."*

Copies may be purchased [prepayment required] from AAIA Technical Information Service Library, 555 West 57th Street, New York, New York 10019, Telephone No. (212) 247-6500. LAR-14497.

Low-Cost Fiber Gyroscopes for Medium-Grade Applications

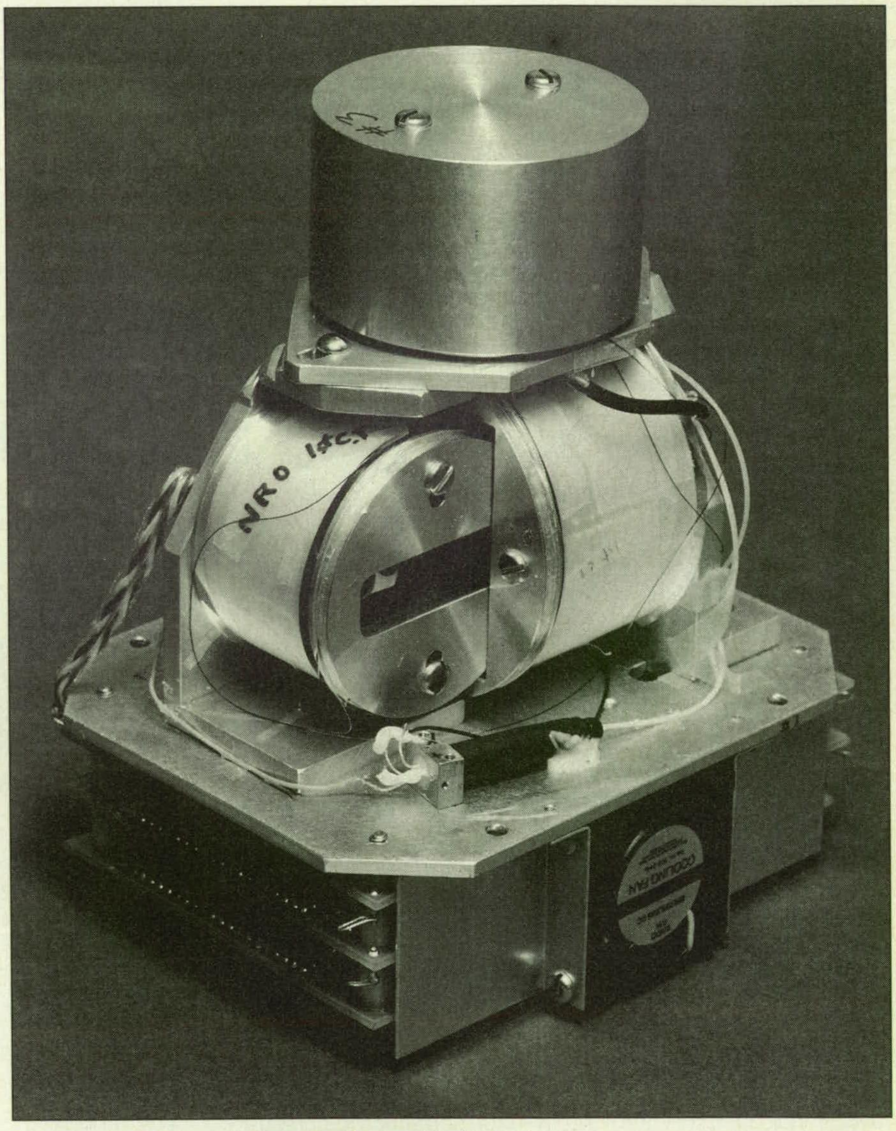
Electronic loop closure allows linear operation from open-loop gyros.

Naval Research Laboratory, Washington, D.C.

A low-cost fiber optic gyroscope has been developed by applying an electronic closed-loop scheme to an otherwise open-loop gyro. This allows a linear output without the use of expensive integrated-optic components. Performance of 10-100°/hr with an output nonlinearity of 0.1% has been demonstrated.

Advantages of this approach include: (1) an all-fiber gyro without expensive components; (2) good linearity and scale-factor stability compared to ordinary open-loop gyros; (3) a low-cost source (1.3-µm LED) and non-polarization-maintaining fiber; and (4) maximum rate of better than 200°/sec.

There has been considerable interest in producing low-cost fiber gyroscopes for medium-to-low-grade applications. Applying an electronic closed-loop (phase-tracking) approach to an open-loop design marries the performance benefits of a closed-loop gyro to the low-cost components of the open-loop kind. The output is true closed-loop and linear, and it does not depend on the optical intensity. All the components are low-cost, including the ELED source, the ordinary fiber in the coil and fused couplers, and the fiber-wound piezoelectric transducer.



Assembled Three-Axis Gyro Package with electronics.

Fiber Lyot depolarizers and a fiber polarizer provide the means for polarization control. The phase-tracking circuit is based on a simple low-cost function generator. The signal from each axis is digitized and multiplexed onto a single output data line. Pitch, roll, and yaw gyros were mounted in a three-axis configuration with the electronics on printed circuit boards. Six three-axis prototypes were built, one of which is shown in the photograph. Each prototype is powered by 15 VDC and has a volume of 70 in^3. The units were intended to operate from 10-100°/hr to more than 200°/sec over a ~25°C temperature range. Good performance was obtained in this range, with a nonlinearity of less than 0.1% of the maximum rate. White noise was 0.07°/$\sqrt{hr}$ for the demodulated output.

The gyro package was developed for a flight-control package in a small model airplane, and intended for short-duration (~15-min.) flights. The gyro package was rocket-launched and operated throughout an acceleration of ~50 g.

This gyro may be manufacturable in the range of a few hundred dollars per axis. Applications might include automobile navigation, AHR (attitude, heading, and reference) systems for small airplanes, robotics, platform stabilization, and so forth.

This work was carried out in the Optical Sciences Division of the **Naval Research Laboratory**. *Patents are pending. For information on rights and licenses contact W. K. Burns, Code 5670, (202) 767-4928; or A.D. Kersey, Code 5670, (202) 767-9307. Inquiries may also be addressed to Dr. Richard H. Rein, Technology Transfer Office, Code 1004, Naval Research Laboratory, Washington, D.C. 20375-5320; (202) 767-3744.*

Discover America's Best New Photonics Technologies At

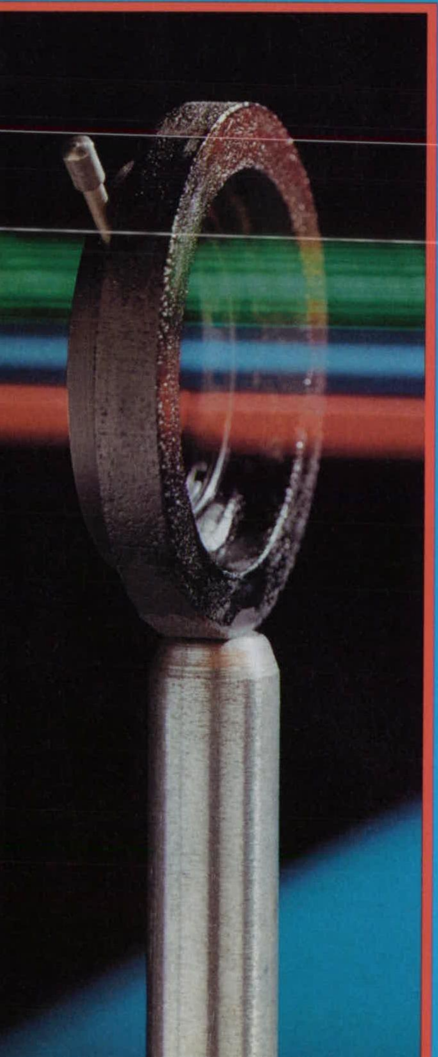
LASERTECH '94

THE PHOTONICS TECH TRANSFER CONFERENCE

NOVEMBER 9, 1994
WASHINGTON, DC CONVENTION CENTER

Sponsored by Laser Tech Briefs *magazine and the Technology Utilization Foundation in cooperation with the Federal Laboratory Consortium for Technology Transfer*

LaserTech '94 will spotlight the latest laser, electro-optics, fiber optics, optics, and imaging technologies developed by U.S. national laboratories and their contractors under the government's $75 billion annual R&D budget.



This information-packed meeting, held in conjunction with the Technology 2004 conference as part of national technology transfer week, will expose a wealth of commercially-promising, licensable inventions from NASA, NIST, the departments of Defense and Energy, and other major government agencies. LaserTech '94 specifically can help you:

- ***find new product ideas and design/manufacturing solutions;***
- ***identify potential partners and funding sources;***
- ***connect with the government's top technologists and tech transfer specialists in the photonics field;***
- ***stay ahead of the technology curve — and the competition — by learning about the latest advances before they reach the market.***

SEE NEXT PAGE FOR PROGRAM AND EXHIBITS

Wednesday, November 9

Washington, DC Convention Center

8:00 AM
Continental breakfast in meeting room. (All room assignments will be listed in the final program distributed on site.)

8:20 AM
Welcome
Robert S. Clark, Editor, and Joseph T. Pramberger, Publisher, Laser Tech Briefs

8:30 AM
Keynote address: "Understanding Industrial Research Opportunities at NIST"
Dr. Katharine B. Gebbie, Director, National Institute of Standards and Technology's Physics Laboratory

Dr. Gebbie, a recipient of the Lifetime Achievement Award from Women in Science and Engineering and formerly a principal investigator on NASA's Orbiting Solar Observatory and Solar Maximum Mission projects, will discuss partnership and technology transfer opportunities afforded by the Advanced Technology Program, the Technology Reinvestment Project, and other major government programs.

9:15 AM
Optoelectronics Roadmap: Markets and Technology to 2013
Arpad Bergh, President, Optoelectronics Industry Development Association (OIDA) and Executive Director, Bell Communications Research
OIDA's "Market Opportunities" (1993) and "Technology Roadmap" (1994) reports climaxed a two-year program of workshops and national forums, attended by more than 500 industry representatives, designed to improve U.S. competitiveness in optoelectronic markets. Find out how you can take advantage of technology advances and market shifts to position your company for growth into the 21st century.

10:00 AM Coffee Break

10:15 AM
The Alliance for Photonic Technology (ATP): Putting Business Needs First
Dr. Connie Giuliano, Executive Director, Alliance for Photonic Technology
The ATP is a consortium for technology transfer comprised of four R&D giants: Los Alamos National Laboratory, Sandia National Laboratories, the University of New Mexico's Center for High Technology Materials, and the Air Force Phillips Laboratory. Dr. Giuliano will describe how the consortium works with industry to commercialize its cutting-edge technologies.

10:45 AM
Seed Capital for Technology Ideas
Carl Nelson, Manager, Small Business Innovation Research (SBIR) programs for the Ballistic Missile Defense Organization
Mr. Nelson is responsible for SBIR awards totalling $45 million annually. Find out how you can tap into SBIR resources at BMDO and other federal agencies to help fund research, design, and development projects.

11:15 AM
Resonetics: An SBIR Success Story
Dr. Ronald Schaeffer, Director of Sales & Marketing, Resonetics Inc.
Learn how Resonetics, an excimer laser design/systems integration/manufacturing facility, successfully obtained SBIR grants to fuel its growth. Profit from their experience!

12.00 PM
Networking Luncheon
Luncheon address: Extending Optical Storage into the Third Dimension
Dr. Hal J. Rosen, Manager, Novel Recording Studies, IBM Almaden Research Corp.

Scientists at IBM's Almaden Research Center have demonstrated new multilevel optical disks that are capable of huge gains in data storage capacities. At today's optical data storage densities, a ten-layer disk would store some 6.5 billion bytes of information — equivalent to more than a million pages of printed text. This would permit feature-length movies to be stored as high-resolution digital video on a single disk, and enable dramatic increases in the capacities of multi-disk optical libraries, or "jukeboxes," used by industry to store trillions of bytes of data with about 10-second access times. Dr. Rosen will describe how it works and outline its many exciting applications.

1:30 PM
Concurrent Technical Sessions

Track #1: Lasers & Laser Systems

1:30 Nd:YLF/MOPA Diode Lasers for Intersatellite Communications
Michael A. Krainak, Head, Optoelectronics Section, NASA Goddard Space Flight Center
Performance and communications test results show that these and other semiconductor lasers developed at Goddard have potential in mobile telephone networks, commercial surveying, construction, and other systems.

1:50 Single-Mode Distributed Feedback Ridge Laser Diode
Siamak Forouhar, Supervisor, Photonics Group, Jet Propulsion Laboratory (JPL)
JPL has developed a novel technique to achieve single-mode diodes without epitaxial re-growth, improving the manufacturability and reliability of devices of many different material systems.

2:10 Completely Solid-State Tunable Ti:Sapphire Laser System
Dr. David V. Guerra, Research Scientist, National Research Council and NASA Goddard Space Flight Center
NASA Goddard scientists have produced a rugged self-contained system that is extremely flexible and provides pulsed output at specific frequencies with low input-power requirements.

2:30 Polygon Mirror-Based Absolute Rotary Encoding Device
Douglas Leviton, AST Engineer, NASA Goddard Space Flight Center
A laser-based encoding device using a polygonal mirror's specular facets will rival state-of-the-art incremental and absolute types and will cost only a fraction of its state-of-the-art counterparts.

Track #2: Test, Monitoring, and Process Control

1:30 Fiber Optic Sensors for Distributed Strain and Vibration Measurements
Dr. Alan D. Kersey, Principal Investigator, Fiber Optic Bragg Grating Sensors, Naval Research Laboratory
These small, high-sensitivity, EMI-immune, high-bandwidth fiber optic

sensors offer unique capabilities for quasi-distributed strain mapping and vibration monitoring in many civil and military applications.

1:50 Fiber Optic Flameout Detector System for Harsh Environments
Stephen E. Borg, Aerospace Technologist, NASA Langley Research Center
Designed to respond to gross changes in combustor light intensity, this flameout detection system can have wide applications in any industrial process where flame on/off conditions are critical to the operation.

2:10 Tunable Laser Spectrometer for Environmental Characterization and Monitoring
Bruce J. Nielsen, Sensor, Site Characterization, & Monitoring R&D Program Manager, Air Force Armstrong Laboratory
Armstrong Laboratory's Environics Directorate has developed a hazardous waste site characterization and monitoring spectrometer whose laser may be tuned to the optimum frequency for the detection of pollutants while minimizing potential interference.

2:30 Optical Product-Grade Sensor for Process Control
D. A. Rice, Supervisory Metallurgical Engineer, U.S. Bureau of Mines Salt Lake Research Center
A unique sensor built by the U.S. Bureau of Mines from conventional readily available hardware measures product grade based on color and texture for manufacturing processes.

2:50 PM Break

3:10 PM

Concurrent Technical Sessions

Track #1: Design & Manufacturing

3:10 Precision Hole Drilling with Copper Vapor Lasers
Jim J. Chung, Physicist, Lawrence Livermore National Laboratory
A new micromachining process from Lawrence Livermore uses a near-diffraction-limited copper vapor laser that results in improved hole quality and better control of size and shape, with precision and surface finish comparable or better than the current widely used electrical discharge machining.

3:30 Pulsed Laser Deposition of Diamond-Like Carbon
Bruce E. Warner, Physicist, Lawrence Livermore National Laboratory
The production of high-quality diamond-like carbon from graphite targets has been demonstrated with a copper vapor laser, indicating that pulsed laser deposition could become an extremely attractive industrial tool for high-value-added coatings.

3:50 "Seamless Engineering" for Mechanical Design and Laser Welding
Jon J. Yagla, Weapons Systems Department, Naval Surface Warfare Center, Dahlgren Division
The method combines welding analysis with stress analysis, through radiant heating models for use in a nonlinear finite-element computer program that could apply to simulation-based designs and manufacturing processes for such projects as a double-hull advanced marine vehicle.

4:10 Nonreclosing Pressure Relief Device for Vacuum Systems
William A. Swansiger, Senior Member, Technical Staff, Sandia National Laboratories
Designed to relieve at pressures from 0.5-2 psig, a range beyond the capabilities of existing nonreclosing devices, the device could be used in advanced manufacturing operations ranging from semiconductor production to diamond synthesis.

Track #2: Electro-Optical and Imaging Systems

3:10 A Bifurcating Self-Amplified Optical Associative Retrieval and Pattern Recognition Technique
Hua-Kuang Liu, Senior Research Engineer, Jet Propulsion Laboratory
An experiment using a barium titanate crystal showed optical edge enhancement, pattern recognition, and autoassociative retrieval phenomena that could be applied to data and image identification, data compression for communications, and industrial quality control.

3:30 New Heavily Fluorinated Resins for Electro-Optical Applications
James R. Griffith, Supervisory Research Chemist, Naval Research Laboratory
These liquid fluorinated resins that can be cured conveniently to strong plastics are particularly well suited for cladding on glass optical fibers and matrix resins for electronic circuit boards.

3:50 Electro-Optic Sample-and-Hold Circuit for High-Speed, High-Precision A-D Conversion
Dr. W. H. McKnight, Engineer, Naval Command, Control, and Ocean Surveillance Center, RDT&E Division
An optically controlled current steering bridge sample-and-hold technique using a laser clock to reduce aperture uncertainty could be an important factor in the development of all-digital radio and television.

4:10 Motorized Mirror-Mount Positioning System
John J. Hardgrove, Staff Engineer, Nike Laser Project, Science Applications International Corp.
Using a processor card-controlled mirror mount, commercial CCD cameras, framegrabbers, and image analysis software, a remote alignment system could provide multiple-axis positioning for optical systems that contain many optical components.

4:30 PM Close Of Program

EXHIBITS

LaserTech '94 attendees will have free access to the Technology 2004 exhibits hall in the Washington convention center during the following show days and hours:

Tuesday, November 8 —
10:00 am to 5:00 pm

Wednesday, November 9 —
10:00 am to 5:00 pm

Thursday, November 10 —
10:00 am to 3:00 pm

The exhibits hall will feature over 80,000 square feet of technologies and products available for license or sale from federal laboratories, universities, and high-tech firms. It will include the LaserTech '94 pavilion of photonics technologies for transfer.

LaserTech '94 attendees can upgrade their registration to attend Technology 2004 symposia and workshops to be held November 8-10. The upgrade fee for preregistrants is $165 (in addition to the LaserTech '94 reg. fee of $120) and includes all Tech 2004 symposia/workshops, a ticket to the 1994 Technology Transfer Awards Dinner on Nov. 9, and a set of Tech 2004 official proceedings. For Tech 2004 program information call Wendy Janiel at (212) 490-3999.

SEE NEXT PAGE FOR REGISTRATION INFO.

Preregister and $ave

	by 10/21	On-site
LaserTech '94 Registration (includes LaserTech '94 symposia, breakfast, lunch, and exhibits.	$120	$140
Technology 2004 (upgrade for LaserTech '94 registrants; includes symposia and workshops (11/8-11/10), Technology Transfer Awards Dinner (11/9), and official proceedings.	$165	$195
Exhibits Only	— No Charge —	

Preregistrants will receive written confirmations via mail along with their name badges and inquiry cards. Badge holders, programs, and dinner tickets must be picked up in person at the Washington, DC convention center (900 Ninth St. NW) beginning at 12:00 pm on Monday, November 7.

Special Hotel Rates

Renaissance Hotel (headquarters)	$125 single/double
Grand Hyatt Washington	$134 single/double
Henley Park Hotel	$100 single/$110 double
Hotel Washington	$99 single/double (govt. only)

To make reservations, call the housing bureau at (800) 535-3336 or (202) 842-2930 and identify yourself as a LaserTech '94 attendee. A $125 per room deposit is required.

Travel Discounts

Budget Rent-A-Car: Call (800) 772-3773 and refer to the rate code #VNRD/TNGY. Valid Nov. 1-17. **Amtrak:** 10% discount. Call (800) USA-RAIL and refer to the fare code #X-84E-927. Valid Nov. 6-12. **USAir:** Book your ticket on USAir to be entered into a drawing for two round-trip tickets good in the continental U.S., Canada, the Bahamas, and San Juan. 10% discount off unrestricted coach fares, and 5% off first class. Call (800) 334-8644, refer to gold file #35380094.

Questions? *Call Wendy Janiel at (212) 490-3999.*

ltb 7/94

LASERTECH '94 PREREGISTRATION FORM

USE A SEPARATE FORM OR PHOTOCOPY FOR EACH REGISTRANT. BE SURE TO ANSWER ALL QUESTIONS BELOW.

Name ______________________________

Title ______________________________

Company ______________________________

Address ______________________________

City/St/Zip ______________________________

Phone No. ______________________________

Which of the following best describes your industry or service? (check one)

- A ☐ Electronics
- B ☐ Computers
- C ☐ Communications
- D ☐ Transportation/Automotive
- E ☐ Aerospace
- F ☐ Defense
- G ☐ Government
- H ☐ Materials/Chemicals
- I ☐ Industrial Equipment
- J ☐ Manufacturing
- K ☐ Power/Energy
- L ☐ Biomedicine
- M ☐ University
- N ☐ Research Lab
- O ☐ Other

specify______________

Which of these products do you recommend, specify, or authorize the purchase of? (check all that apply)

- P ☐ Lasers
- Q ☐ Laser Parts & Accessories
- R ☐ Laser Systems
- S ☐ Optical Components
- T ☐ Detectors/Sensors
- U ☐ Cameras
- V ☐ Imaging/Display Equipment
- W ☐ Test & Measurement Equip.
- X ☐ Electronics & Signal Analysis Equip.
- Y ☐ Positioning & Support Equipment
- Z ☐ Materials and Substrates
- 1 ☐ Vacuum & Gas Handling Equipment
- 2 ☐ Fiber Optic Components & Systems

Your principal job function is: (check one)

- A ☐ General & Corporate Management
- B ☐ Design & Development Engineering
- C ☐ Engineering Services - Tests/Quality
- D ☐ Basic Research
- E ☐ Manufacturing/Production
- F ☐ Purchasing/Procurement
- G ☐ Other

specify: ______________

Please register me for the following: (check all that apply)

- F ☐ LaserTech '94 Registration $120
- G ☐ Technology 2004 upgrade fee .... $165 (LaserTech '94 registrants ONLY.)
- E ☐ Exhibits Only .... Free

TOTAL: $ ______________

☐ Check/MO enclosed (payable to Technology Utilization Foundation)

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Card No. Expire Date

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Signature Date

Registrations are transferrable and may be cancelled until October 21, 1994. After that date no cancellations will be refunded.

Return with payment to: Technology Utilization Foundation c/o LaserTech '94, PO Box 614, Brookfield, IL 60513-0614

FOR FASTEST REGISTRATION FAX TO: (708) 344-9482

FABRICATION

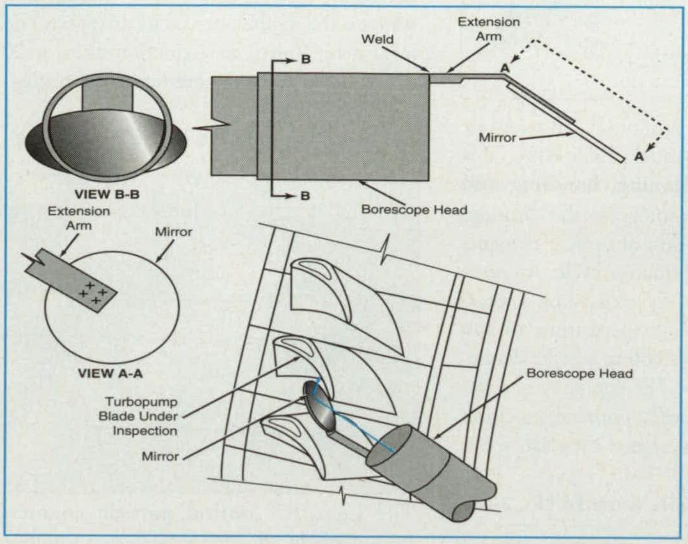
Mirror Attachment for Borescope

The mirror makes it possible to look to the side of the borescope.

Marshall Space Flight Center, Alabama

An attachment for an articulated borescope provides views into small, normally inaccessible spaces. The attachment is a simple small round mirror on an extension arm welded to the borescope head. Tilted at an angle to the axis of the borescope head, the mirror can provide views sideways to the borescope head.

The attachment was devised for inspecting the concave inner surfaces of the blades of a turbopump (see figure). The opening between blades is too small to admit the 11-mm-diameter borescope used to inspect other parts of the pump. The mirror can enter these openings, however, where it reflects ultraviolet light from the borescope onto the blades and reflects a view of the blades back into the borescope. Cracks in the blade surfaces, which have been treated with a penetrant dye, become visible as bright fluorescent areas. Disassembly of the turbopump blades is therefore not necessary to enable fluorescent-penetrant-dye inspection.



The Mirror Reflects views of previously inaccessible areas into a borescope. The mirror is tack-welded and bonded by epoxy onto its supporting arm, which is welded onto the borescope head.

The attachment has also been used to inspect difficult-to-reach internal parts of other assemblies. It can also be used for inspection with ordinary white light.

This work was done by John F. Gearhart and James E. Peloquin of United Technologies Corp. for **Marshall Space Flight Center.** *No further documentation is available. MFS-28821.*

Optically Aligned Drill Press

A drill is simply prealigned and rotated into position.

Langley Research Center, Hampton, Virginia

A precise drill press is equipped with a rotary-indexing microscope for prealigning the drill bit. The apparatus ensures that small holes, ranging from 0.002 to 0.030 in. (0.05 to 0.76 mm) in diameter, are located precisely. It is used, for example, to drill instrumentation orifices in model aircraft for wind-tunnel tests.

Previously, the drill bit was positioned by viewing its tip, in relation to the target position on the workpiece, through a handheld magnifying glass. This procedure was subject to error from both visual distortion of the magnifier and the parallax introduced by the viewing angle. The procedure was also time-consuming, requiring as much as 20 minutes to position the drill for one hole.

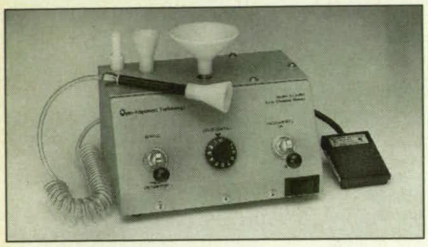
The new microscope is mounted on a turret with the drill (see figure). The operator indexes the turret so that the microscope is approximately over the site of the hole. Looking through the microscope, the operator centers its crosshairs on the site by adjusting the angle and position of the turret. The operator then simply indexes the turret so that the drill bit rotates into the position formerly occupied by the line-of-sight of the microscope. The new procedure takes less time to locate drilling poisitions and produces more accurate results. The apparatus can be adapted to such other machine tools as milling and measuring machines.

This work was done by Bruce M. Adderholdt of **Langley Research Center**. *No further documentation is available.*

Inquiries concerining rights for the commercial use of this invention should be addressed to the Patent Counsel, Langley Research Center [see page 8]. Refer to LAR-14182.

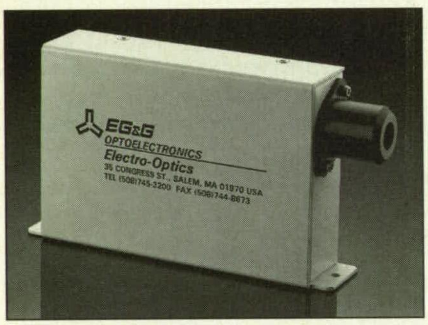
The Microscope and Drill Exchange Places when the turret is rotated. The microscope axis is first aligned over a future hole, then rotated out of the way so that the drill axis assumes its precise position.

NEW PRODUCT SHOWCASE



Opto-Alignment Technology, Rochester, NY, offers the Model LCS-002 Lens Handler™ **optics cleaning, handling and assembly center** that integrates the cleaning, painting and installation of optical elements into one smooth continuous cycle. An optical element is secured by vacuum on a rotating spindle with variable speed from 40-200 rpm. A wide range of tooling accepts diameters from 1-300 mm. The company also has a line of Opto-Wipes™, reusable precision lens cleaning wipes designed for clean room environments.

For More Information Write In No. 801



New from EG&G Electro-Optics, Salem, MA, is the 1100 series FlashPac™ family of packaged **xenon flashlamp modules**. The company says the modules feature exceptional arc stability, continuous spectrum output over the UV-VIS-IR, long life, low heat radiation, and fiber optic coupling. The 1100 series is suitable for absorption analysis, immunoassay systems, spectroradiometry, liquid and gas chromatography, and more.

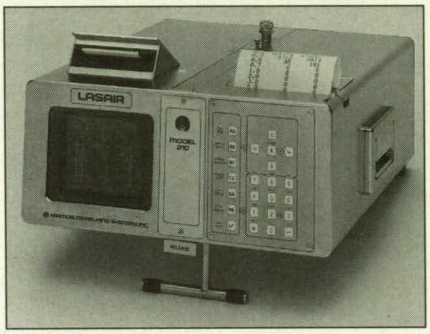
For More Information Write In No. 802

Now available from Virgo Optics, Port Richey, FL, is **neodymium-doped yttrium vanadate ($Nd:YVO_4$)**. Grown by Union Carbide Crystal Products, the material has a high absorption coefficient at 807 nm and highly polarized output at 1064.3 and 1320 nm. Low-loss high-reflection/high-transmission, partial-reflection, and antireflection dielectric coatings are offered, and volume fabrication of rods, parallelpipeds, and prisms can be done.

For More Information Write In No. 803

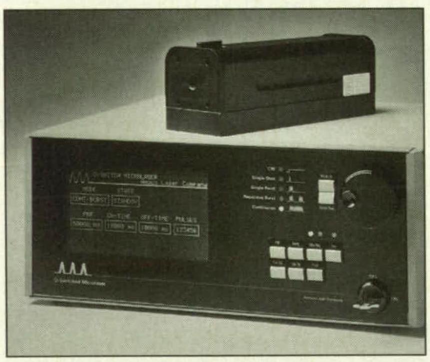
Gould Fiber Optics, Glen Burnie, MD, has announced improvements of its 2.5-GB/s **digital modulator**. Designed for compatibility with GaAs driver chips that simplify device integration into OC48 transmission systems, the modulator and its driver have no measurable chirp, an extinction ratio of 20 dB at the bit rate, no overshoot, and negligible signal droop.

For More Information Write In No. 804



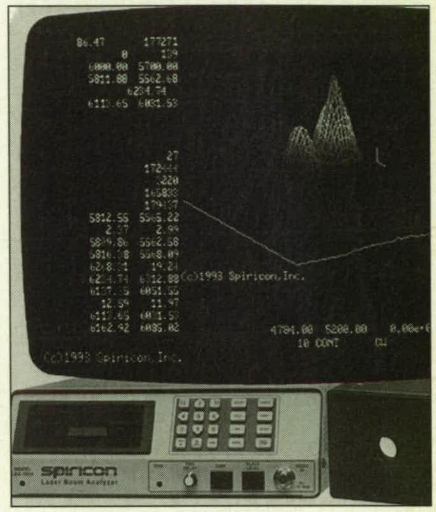
The LASAIR™ **optical particle counters** from Particle Measuring Systems, Boulder, CO, are designed for contamination monitoring in cleanroom facilities. These aerosol instruments make the passive laser cavity and sample flow cell am integral assembly easily removed for servicing. Sizing thresholds are available at 0.1, 0.2, 0.3, and 0.5 microns at sample flow rates from 0.002-1 cf/min.

For More Information Write In No. 805



Amoco Laser Products Group, Naperville, IL, introduces an air-cooled **diode-pumped solid-state Q-switched microlaser** to address diverse trimming, cutting, and welding applications. The power supply/control unit produces adjustable output from 0-100 percent with an adjustable repetition rate from 1 Hz-50 kHz. Operating at 1053 nm with up to 250 µJ per pulse, the laser features peak power and short pulsewidth designed for semiconductor processing, marking, and trimming.

For More Information Write In No. 806



A new **pyroelectric solid-state camera for IR laser beam analysis** comes from Spiricon, Logan, UT. Pyrocam I's 124-X-124-pixel matrix array on 100-µm centers yields an overall dimension of 12.4 X 12.4 mm. The sensor, sensitive to all wavelengths from the near to the far infrared, is especially useful for OPO, Er:YAG, chemical, carbon dioxide, and other far-IR lasers, the company says. The camera's built-in microprocessor provides standalone operation, wide spectral response, and high energy capability. The unit interfaces to Spiricon's LBA-100A beam analyzer.

For More Information Write In No. 807

Korry Electronics, Seattle, WA, is offering its Excilite™ **tunable solid-state dye laser host**. The company says the material offers all the performance of liquid dye with no solvents, no complicated circulation systems, and no special handling or disposal problems. A range of dyes and geometries is available for what the company calls cost-effective wavelength shifting.

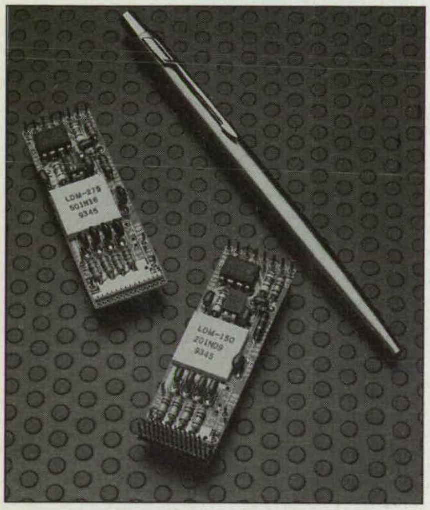
For More Information Write In No. 808

The new family of **digital position sensing detectors (DPSDs)** from E&G Heimann Optoelectronics, Wiesbaden, Germany, uses amorphous silicon thin film technology to eliminate the analog resistive layers of conventional devices, making them intrinsically linear over the entire measuring area. The DPSDs are sensitive from 400-700 nm and semitransparent between 600-700 nm. Offered as a modular unit of sensor, signal-processing unit, and microcontroller, the devices can be used to determine the centroid position of a light spot.

For More Information Write In No. 809

Data Optics, Ypsilanti, MI, announces a line of **Environmental Isolation Enclosures** that deal with variations in environmental parameters that vibration-isolated optical tables do not affect. The enclosures reduce air turbulence, acoustic noise, airborne pollutants, humidity fluctuations, and temperature drift. The units are built to order from standard components, adding optional ports for laser beam entry, wire feedthrough, and viewing.

For More Information Write In No. 810



The LDM series **laser diode driver modules** from Directed Energy, Fort Collins, CO, are an OEM product designed so that the current pulses may be easily tailored to the diode type and application. Appropriate for extremely fast high-current pulse delivery for rangefinders, lidar, pulsed Doppler, and other applications, the drivers can be configured so that values range from 3-ns rise time, 6-ns pulsewidth, and 20-40 A to 6-ns rise time, 100-ns pulsewidth, and >100 A.

For More Information Write In No. 811

The C5658 module from Hamamatsu Corp., Bridgewater, NJ, combines an **avalanche photodiode detector** with a high-speed amplifier and bias power supply on a compact board. The amp's +/-3-dB bandwidth is 1 MHz-1 GHz, and typical temperature stability is +/-5 percent. Active APD area is 0.5 mm in diameter, and the unit is available with a fiber optic connector.

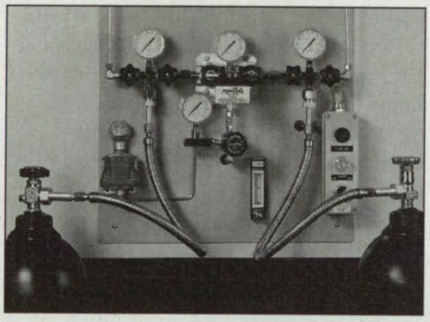
For More Information Write In No. 812

The new T-350, T-350 portable, and T-700 **thermoelectric recirculating chillers** from ThermoTek Inc., Carrollton, TX, offer cooling from 4-30 °C with capacities from 350-700 W. The company says the chillers are 50 percent lighter than compressor-based systems. They feature leak-free quick connections, positive displacement or centrifugal pumps, enhanced PID control, no compressor maintenance, and quiet operation. Options include RS-422 remote control, rack-mount kits, and extended temperature and heat-pumping ranges.

For More Information Write In No. 813

Honeywell's Micro Switch Division, Freeport, IL, says its new GP5 series of **photoelectric sensors** has extended scanning ranges of up to 23′ for retroreflective, 13.1′ for polarized retroreflective, 3.2′ for diffuse, and 49.2′ for through scan. Designed for global applications, they have universal voltage (12-240 VDC, 24-240 VAC), a 3-A SPDT relay output, and comply with IP66 and NEMA 4 enclosure seal standards, as well as IEC global noise and ambient-light standards. List price is $60-125 and they are available from stock.

For More Information Write In No. 814



Air Products and Chemicals, Allentown, PA, says continuous uninterrupted high-purity gas delivery of carrier, calibration, or process gases can be effectively maintained with its new **automatic changeover regulator**. It maintains gas integrity through a unique purge assembly that allows independent purging of the system after cylinder change-out. Suitable for laboratory or remote locations, the sturdily constructed regulator typically is used in laser gas systems, gas and liquid chromatography, and semiconductor process gases.

For More Information Write In No. 815

The newest additions to the line of ruggedized commercial off-the-shelf **multifunction optical drives** from Mountain Optech, Boulder, CO, are the SE-1000 Rev 3 and the ST-1000 Rev 3. Designed for rugged airborne, shipboard, or ground applications, the Rev 3 line complements 1.3-Gbyte capacity with faster access. The company says the SE-1000/ST-1000 can operate over a wider temperature range than commercial drives.

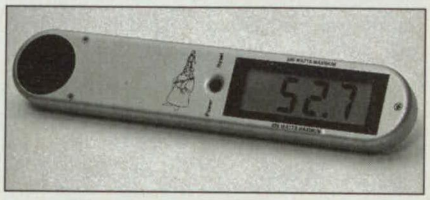
For More Information Write In No. 816

The STI/Elesta 72 series of self-contained **photoelectric sensors** fits in the same space as other 18-mm sensors, says Scientific Technologies, Hayward, CA. But in addition to standard through-hole mounting, the sensor also allows surface mounting. The Sensing modes include through-beam, diffuse reflective, reflex, and polarized reflex versions. Adding more flexibility, says the company, the series is available with straight optics for end-sensing and right-angle optics for side-sensing.

For More Information Write In No. 817

The new TimeMaster **fluorescence lifetime spectrometers** from Photon Technology International, South Brunswick, NJ, have open architecture design. The StrobeMaster™ uses a proprietary strobe technique to measure lifetimes from 200 psec to 750 nsec. The LaserStrobe™ has a dye laser excitation source for enhanced sensitivity. The TCSPC-1000™ uses time-correlated single-photon counting. All the systems can be expanded to perform steady-state fluorescence and ratio fluorescence studies.

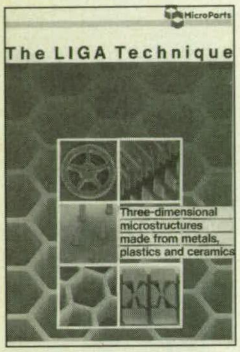
For More Information Write In No. 818



Synrad, Bothell, WA, says its PW-250 Power Wizard is the first **pocket-size laser power probe** that can measure wavelengths from excimer to carbon dioxide with power inputs of up to 250 W. The self-contained digital probe has a built-in analog computer capable of instant recycling, making sequential readings possible. Required exposure time is less than 5 s. Features include digital display, autoranging, and auto shutoff.

For More Information Write In No. 819

NEW LITERATURE



American Laubscher Corp. (ALC), Farmingdale, LI, NY, is distributing literature from the German company MicroParts providing information on the applications of the proprietary LIGA process, which creates three-dimensional microstructures from metals, plastics, and ceramics by combining **lithography, electroforming, and plastic molding**. Among the products described are sensors, fluid components, and components for microelectronics, microoptics, and integrated optics. The technique has produced what ALC calls the first low-cost mass-producible diffraction-grating-based miniature spectrometer element.

For More Information Write In No. 710

Available from ACI Systems, Englewood, CO, U.S. distributor for Kimmon Manufacturing Co., is an 8-page full-color brochure and specification sheet describing a series of **helium cadmium lasers**. The IK lasers include the blue series, emitting at 442 nm, with TEM_{00} or multimode options, and rated powers from 15-170 mW. The ultraviolet series emits at 325 nm, with TEM_{00} and multimode options and rated powers from 8-100 mW. A dual-wavelength model is offered. Kimmon says average lifetime is 5000 hours.

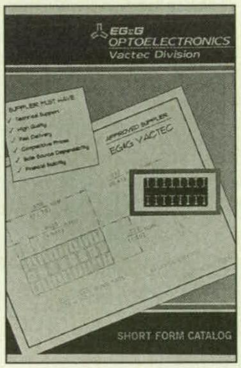
For More Information Write In No. 711

The capabilities of Optics One, Westlake Village, CA, in **optical and optomechanical design and engineering** are the subject of a 12-page full-color pamphlet. Included are details on facilities, labs, engineering specialties, projects and applications, assembly, test and measurement. Optics One also markets PT-01™, described as a "personal theater system": a lightweight head-mounted video display for NTSC video, computer imagery, IR thermal imagery, and more.

For More Information Write In No. 712

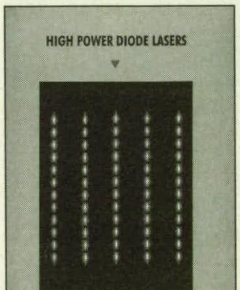
A 16-page full-color illustrated brochure from Rocky Mountain Instruments, Longmont, CO, outlines the company's capability to produce **custom, standard, and OEM laser and imaging optics and systems**. It presents details on optical design and fabrication, materials, (UV through IR), coatings, assemblies, research and development, quality assurance processes, and custom solutions to client requirements.

For More Information Write In No. 713



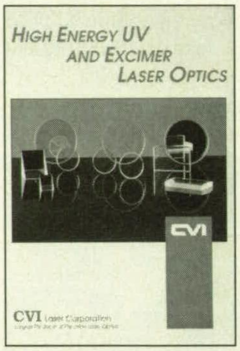
EG&G Optoelectronics, Vactec Division, St. Louis, MO, has made available a 12-page short-form catalog that supplies electrical and optical characteristics, features, and typical applications of its complete **optoelectronic line** of silicon photodiodes, IR emitters and phototransistors, CdS photoconductive cells, Vactrol® analog optoisolators, optoswitches, optical hybrids, and custom opto assemblies.

For More Information Write In No. 714



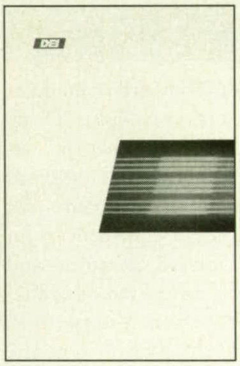
SPIRE Corp., Bedford, MA, announces the availability of a six-page color brochure on **high-power diode lasers**. Mechanical and operating specifications on the extensive line of high-power pulsed and CW laser products are accompanied by performance data and information on packaging and the company's research and development programs.

For More Information Write In No. 715



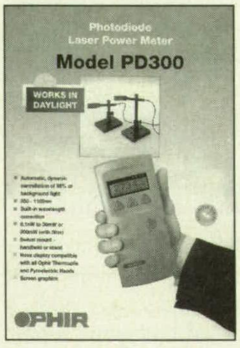
CVI Laser, Albuquerque, NM, has released a 92-page catalog of its **high-energy UV and excimer laser optics**. Included are flats, windows and window blanks, Brewster windows, mirrors and mirror blanks, prisms, beamsplitters, bandpass filters, coatings, and more. Along with purchasing information, the catalog has information on specifications, optical materials, indices of refraction, and dispersion equations.

For More Information Write In No. 716



Directed Energy, Fort Collins, CO, has produced a series of new product information and specification sheets on its product lines. Included are the LDX **laser diode driver**, the GRX-1.5K-E and GRX-3.0K-E **time-of-flight pulse generators**, and the DE Series **MOSFETs**. Specifications include output information, pulse characteristics, and rise times. The sheets also describe operation of the units.

For More Information Write In No. 717



Ophir Optronics, Peabody, MA, is offering a full-color descriptive specification sheet on its Model PD300 **photodiode laser power meter**. The sheet points out that the Nova display cancels 98 percent of background signal under normal room lighting conditions even when changing continuously. Maximum power, spectral range, power scales with and without a removable filter, and accuracy are detailed.

For More Information Write In No. 718

INDUSTRY LEADERS

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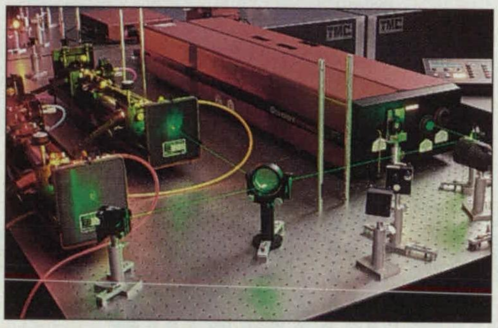
Unique in the industry, we make our products in our own total manufacturing environment. We design and build our own specialized machine tools and fixtures to streamline critical fabrication processes. This capability enables us to create standard and custom products with optimal efficiency, quality, and cost control.



Contact: Steven Ryan, V.P. Mktg., Technical Manufacturing Corp., 15 Centennial Drive, Peabody, MA 01960-7901. Tel: 800-542-9725; Fax: 508-531-8682.

CORECO INC.

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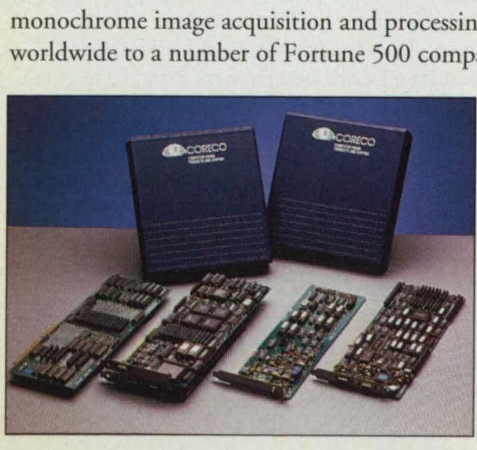
Coreco Inc. has been designing and manufacturing high-performance imaging boards for the PC market since 1983. Coreco's commitment to quality and innovation, and to providing cost-effective solutions to imaging problems, has resulted in the OCULUS line of true-color and monochrome image acquisition and processing boards. Sold worldwide to a number of Fortune 500 companies, Coreco's products are recognized as the industry's best-value high-resolution image acquisition boards.



Contact: Philip Colet or Ralph Tesson, Coreco Inc., 6969 Trans-Canada Highway, Suite 113, St. Laurent, Quebec, Canada H4T 1V8. Tel: 1-800-361-4914 or 514-333-1301; Fax: 514-333-1388.

Based on a unique input architecture that digitizes both standard and nonstandard video sources at resolutions up to 4k x 4k, Coreco's products are ideally suited to quality control, industrial inspection, robotics, machine vision, medical imaging, and high-end scientific or research applications. Resulting images can be stored to disk, processed, or displayed on standard VGA monitors at 1280 x 1024.

All of Coreco's board-level products ship with TC-Pro, a Windows 3.1 application that offers functions such as image acquisition, image storage and retrieval, range and offset controls, and a library of image processing functions. As well, Coreco's products are supported by a device-independent software interface and a library of C-callable functions. Support is provided for most third-party software packages including Accuware, Image-Pro Plus, Optimas, Visilog, and Concept VI for National Instruments.

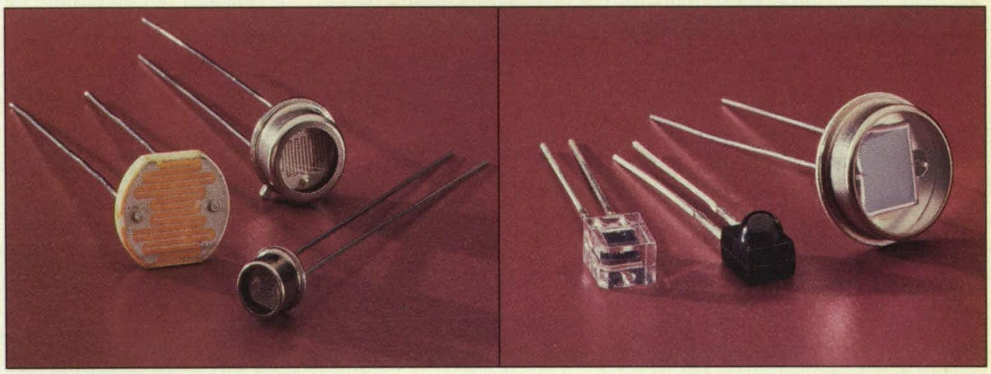
EG&G VACTEC

DEPENDABLE, COST-EFFECTIVE OPTO DEVICES & ASSEMBLIES

EG&G Vactec is based in St. Louis, Missouri, and was originally founded as Vactec, Inc., in December 1959. The company today is one of the oldest active optoelectronic operations in the world, second only to Hewlett-Packard. Acquired by EG&G in 1983, it currently occupies a 80,000-sq.-ft. facility as its headquarters. Vactec also operates a high-volume fabrication and assembly operation in the Philippines which offers additional manufacturing capability for many major global OEM customers.

With vast application possibilities, Vactec products include photocells, silicon photodiodes and arrays, phototransistors, photodarlingtons, IR light-emitting diodes, slotted switches, retroreflective switches, analog optoisolators, and custom opto assemblies. These products are used for automotive, streetlight and security lighting controls, smoke detectors, audio AGC controls, camera exposure and auto focus control, medical/chemical photometry, object counters, colorimetry sensors, and a wide range of other applications.

For more than 30 years, the company has led the way by understanding optoelectronic technology and fine-tuning its manufacturing to produce some of the most dependable, cost-effective opto devices and assemblies available today. Vactec is flexible enough to focus on the newest custom opto requirement, yet large enough to be America's leading photodiode and photocell supplier.



Contact: Linda Schellenger, EG&G Vactec, 10900 Page Blvd., St. Louis, MO 63132. Tel: 312-423-4900. Fax: 314-423-3956.

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SEPTEMBER 15-16, 1994

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Photonics industry attendees at this one-and-a-half-day conference/workshop, the first in a planned series, will come face to face with advanced laser, optoelectronic, and imaging technologies developed initially for the space program that hold promise for commercial exploitation. The program will feature:

- Inventors and technical program managers from Goddard Space Flight Center in individual and roundtable sessions;
- Researchers, patent counsel, and technology transfer experts available for one-on-one discussions of commercialization opportunities;
- A "networking reception" for all participants on September 15.

BRINGING TOGETHER

From NASA Goddard Space Flight Center:

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• Designers, engineers, and technology managers whose companies are searching for innovative ways to develop and test new products, improve manufacturing/production processes, initiate new business lines.

For more information on attending, write in 692 on the Reader Information Request Form.

LITERATURE SPOTLIGHT

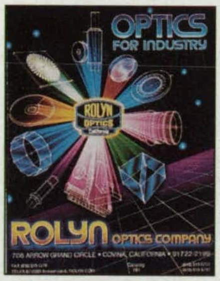
Free catalogs and literature for Laser Tech Briefs' readers. To order, write in the corresponding number on the Reader Information Request Form (page 55).

ADVANCED SOLID STATE IMAGE SENSORS

The growing family of solid-state image sensors from Kodak is presented in two free brochures: A brief overview of high-resolution CCD image sensors including full frame, interline, linear, and infrared; and a simplified product guide for technical specifications. Tel: 716-722-4385, ext. 260.

Eastman Kodak Company
Microelectronics Technology Div.

For More Information Write In No. 300



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Rolyn Optics Co.

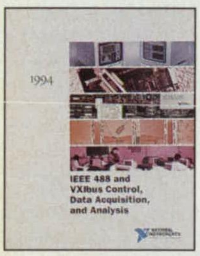
For More Information Write In No. 301

AUTOMATIC OPTICAL TESTING

OPTOMATIC is the first fully-automated test instrument featuring fast, ultra-accurate, objective performance characterization of optical components and lens systems. Focal length, flange focal length, radius of curvature, angles and power of wedges and prisms, MTF and centering errors can be precisely measured. Typical accuracy of 0.05% for focal length, 0.002 diopter for power of prisms and less than 1 arc sec. for angles.

Mildex Inc.

For More Information Write In No. 302

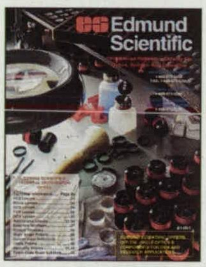


COMPUTER-BASED INSTRUMENTATION

Free 1994 catalog of hardware and software for computer-based instrumentation. Features software for Windows, Windows NT, Macintosh, UNIX, and DOS, including LabVIEW, LabWindows, and the new LabWindows/CVI. Describes IEEE 488.2 interfaces, plug-in data acquisition boards, VXIbus controllers, and signal conditioning accessories. Customer education classes also detailed. Includes tutorials and glossary.

National Instruments

For More Information Write In No. 303

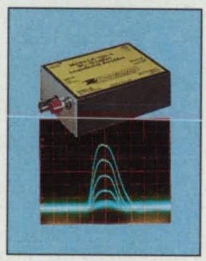


NEW! OPTICAL REFERENCE CATALOG

Edmund Scientific's free 236-page, full-color annual reference catalog features one of the largest selections of precision off-the-shelf optics and optical instruments, plus a complete line of components and accessories for both large-volume OEM users as well as smaller research facilities and optical laboratories. It contains over 8,000 hard-to-find items, including a large selection of magnifiers, magnets, microscopes, telescopes, and accessories. Tel: 609-573-6280; Fax: 609-573-6295.

Edmund Scientific Co.

For More Information Write In No. 304



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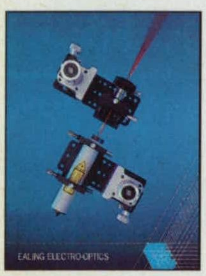
The compact Model LA-100 features wide dynamic range, fast rise time and excellent linearity, making it ideal for laboratory, portable, or multichannel embedded applications. Exclusive One-touch Autonull design suppresses dynamic-range robbing input offset at the simple touch of a button. Tel: 908-788-8445; Fax: 908-788-7521. ElectroSolutions, Inc., 7 Holly Court, Flemington, NJ 08822.

ElectroSolutions, Inc.

For More Information Write In No. 305

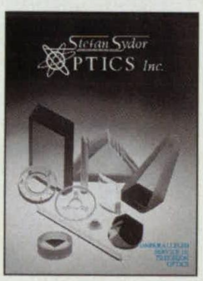


EALING PRODUCT GUIDE

Ealing's Product Guide devotes over 400 pages, covering in excess of 3,500 items, to optical and electro-optical products. Included are lenses, mirrors, filters, high precision positioners, optical mounts, microscope components, HeNe lasers, laser diodes, optical tables, optical benches, and light sources. Ealing Electro-Optics 800-343-4912.

Ealing Electro-Optics, Inc.

For More Information Write In No. 306



Fabricates optical components including flats, filters, lenses, magnifiers, mirrors, prisms, and windows; optical materials including filter glass, quartz, silica, silicate glass, and IR & UV materials. Repairs and refurbishes laser rods. Grinding & polishing service for all types of crystals. Capabilities include double sided grinding and polishing on machines up to 48 in. diameter.

Sydor Optics, Inc.

For More Information Write In No. 307

SPECIALTY GAS AND EQUIPMENT CATALOG

Free! The 1993 rare and specialty gas and equipment catalog from Spectra Gases of Irvington, NJ, contains specifications on rare gases, excimer laser gas mixtures, halogen gas premixtures, helium-3 and isotopic gases, research gases and mixtures, gas safety cabinets, and automatic and manual gas-handling systems. Krypton and argon ion-laser tube remanufacturing, halogen scrubbers, and "oil-free" vacuum pumps are highlighted.

Spectra Gases

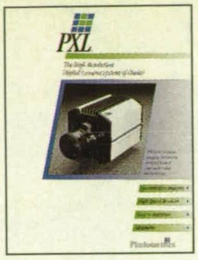
For More Information Write In No. 308

FREE LIGHT RESEARCH CATALOG

Oriel's new Volume II Product Guide: **Light Sources, Monochromators & Detection Systems** is a 528 page technical reference manual and product catalog in one. New, technically advanced products to make, move and measure light include UV to NIR pulsed light sources, nitrogen and tunable dye lasers, calibrated irradiance sources and single and dual beam scanning spectrophotometers. Tel: 203-377-8282. Fax: 203-375-0851.

Oriel Corporation

For More Information Write In No. 334



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Photometrics

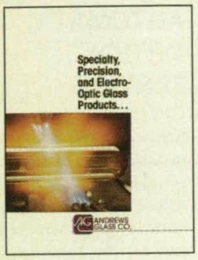
For More Information Write In No. 335

LASER POWER/ENERGY METER

The patented DigiRad R-752 laser power/energy meter measures from 20 µW to 100 W and from 100 nJ to 1 J throughout the spectrum. It features fast response, high damage threshold, rechargeable battery or line operation, RS-232 link plus an integral high-speed waveshape detector. Terahertz Technologies Inc., 169 Clear Road, Oriskany NY 13424. Tel: 315-736-3642; Fax: 315-736-4078.

Terahertz Technologies Inc.

For More Information Write In No. 336

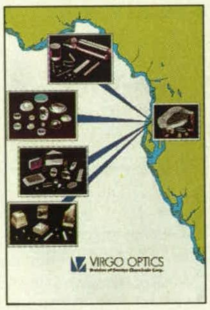


SPECIALTY, PRECISION, AND E-O GLASS PRODUCTS

New four-page brochure describes Andrews Glass capabilities for producing glass products for the research and OEM markets. Precision bore tubing, special envelopes, and other glass or quartz products are fabricated to meet custom specifications. Operations include: precision grinding, lapping, and polishing; glass-to-glass and glass-to-metal seals; and hand tooling. Prototypes and short runs are a specialty. Tel: 800-845-0026.

Andrews Glass Company

For More Information Write In No. 337



VIRGO OPTICS—QUALITY ACROSS THE SPECTRUM

This 91-page catalog illustrates our wide variety of laser optics, coatings, crystals, and custom services. Optical components include waveplates, lenses, mirrors, etalons, and windows. Dielectric or metallic coatings are available for the 190-3200 nm region. Crystal products include Nd:YAG, $Nd:YVO_4$, $KNbO_3$, and $BaTiO_3$. Tel: 813-845-3402; Fax: 813-845-4957.

Virgo Optics

For More Information Write In No. 338

PC IMAGING BOARD

Literature is available for the 4MEG VIDEO Model 12 image capture, processing and display board for the PC. The Model 12 features sampling/display rates up to 50 MHz, 64 Mb of image memory and 50 MHz processor. The Model 12 interfaces to most sources for single or sequential image capture. The literature describes features of the Model 12, along with information regarding software and interface options.

EPIX Inc.

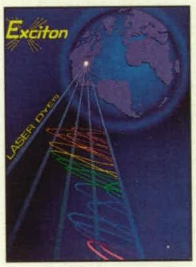
For More Information Write In No. 339

PERFECT OPTICAL ALIGNMENT MADE SIMPLE

The Lateral Transfer Hollow Retroreflector from PLX is a perfect device for applications such as boresighting, beam alignment, and beam delivery, where critical alignment of one optical axis to another is required. Once installed in your system, the LTHR never needs adjustment. Our new technical booklet explains this unique instrument. Tel: 516-586-4190; Fax: 516-586-4196. International area code: 01.

PLX Incorporated

For More Information Write In No. 340



LASER DYES

With Exciton, you get a specialized team of professionals knowledgeable in the field of laser dyes. Since more than one dye may cover a given spectral region, we provide the latest information concerning the best dye selection for a specific laser system and application. Exciton Inc., PO Box 31126, Overlook Station, Dayton, OH 45431.

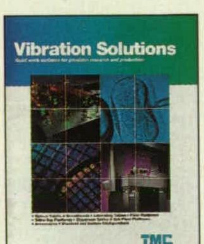
Exciton Inc.

For More Information Write In No. 341

A 100-plus page, full color HIGH PERFORMANCE CAMERAS catalog from Princeton Instruments, Inc., Trenton, NJ, is now available. Slow scan imaging CCD cameras with spectral response from x-ray to the NIR, and with applications from microscopy to astronomy, are outlined. The catalog also provides the specifications for the more than thirty different CCD chips offered in Princeton Instruments, Inc. cameras and useful application notes to help in the selection of a camera system.

Princeton Instruments, Inc.

For More Information Write In No. 342



VIBRATION ISOLATION SYSTEMS

TMC's new 48-page, 4-color product catalog describes its complete line of vibration isolation systems, including optical and laboratory tables, table-top and floor platforms, and suspension systems. Illustrations feature technical insights, performance charts, specifications, R&D and manufacturing data. An applications guide and custom capabilities are also included. Send for the In-dustry Standard. Tel: 800-542-9725; Fax: 508-531-8682.

Technical Manufacturing Corp.

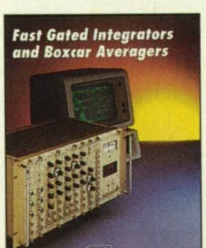
For More Information Write In No. 343

HIGH POWER SMALL PACKAGE HeCd LASERS

Omnichrome again is the leading innovator in Helium Cadmium Lasers by offering the highest power, smallest package 442 nm, 354 nm, and 325 nm, and Simultaneous Dual Line UV/VIS lasers available. All internal mirror, rugged, standard and custom configuration lasers are built for OEMs demanding reliability yet still ideal for research and scientific applications requiring flexibility. Tel: 909-627-1594, 800-525-OMNI; Fax: 909-591-8340.

Omnichrome

For More Information Write In No. 344



GATED INTEGRATOR/ BOXCAR AVERAGERS

The SR250 family easily measures subnanosecond events within a NIM format. Modules include the gated integrator (gates from 2 ns to 15 µs), fast sampler (gates to 100 ps), analog processor, gate scanner, fast preamplifier, and computer interface (with RS-232 and IEEE-488). The SR270 (DOS) software package allows system set-up and control, data display, and post-acquisition data reduction. Tel: 408-744-9040.

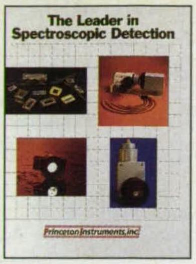
Stanford Research Systems

For More Information Write In No. 345

HIGH-PERFORMANCE IMAGE PROCESSING BOARD

Discover Coreco's new Oculus-F/64 high-performance PC-based image acquisition and processing board. Incorporating a DSP, GSP, real-time histogram processor, and Coreco's proprietary IP-engine, the F/64's innovative design provides maximum processing power for high-end scientific, medical, and industrial image processing applications. Coreco, 6969 Trans-Canada Highway, St. Laurent, PQ, Canada H4T IV8.

Coreco
For More Information Write In No. 346



SPECTROSCOPIC DETECTORS

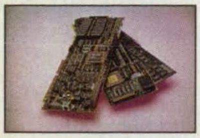
Our new full-color catalog describes our many different detector designs, each optimized for a particular spectrometric detection requirement, and all available from Princeton Instruments, Inc. The fields of spectroscopy covered in this catalog are: CW low-light, pulsed, absorbance, high-speed, x-ray, VUV, and NIR. Princeton Instruments, Inc., 3660 Quakerbridge Rd., Trenton, NJ 08619. Tel: 609-587-9797; Fax: 609-587-1970.

Princeton Instruments, Inc.
For More Information Write In No. 347

INTENSIFIED CCD CAMERAS

Send for our new full-color brochure describing our line of fiber-coupled and lens-coupled cooled, slow-scan intensified CCD cameras. With sensitivity as high as 80 counts per photoelectron, 16-bit dynamic range, and 5-nanosecond gating, these cameras make Princeton Instruments the world leader in cooled, slow-scan intensified cameras. Tel: 609-587-9797; Fax: 609-587-1970.

Princeton Instruments, Inc.
For More Information Write In No. 348



NEW XPG-1000 POWER GRABBER

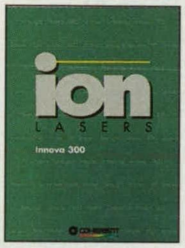
The XPG-1000 Power Grabber is the newest family of imaging boards from Dipix for VESA Local Bus (VL) and ISA bus PCs. Incorporating TI TMS320C40, the XPG-1000 offers flexible frame grabbing at up to 48 MBytes/sec (or 48 MHz) from most standard and nonstandard cameras. It provides up to 256 MB of flexible image memory and an optional display board with Super VGA chip set. Tel: 613-596-4942; Fax: 613-596-4914.

Dipix Technologies, Inc.
For More Information Write In No. 349

LASER TECHNOLOGY AND APPLICATIONS

An 18-page brochure available from Rofin Sinar, Inc. provides a concise examination of laser technology and its expanding applications in the manufacturing environment. Detailed are the elements and concepts of lasers critical to modern industry: versatility and flexibility; precision, control, and speed; and the laser's present and potential applications in welding, cutting, drilling, surface treatment, and product identification. Individual sections discuss CO_2 and Nd:YAG lasers, laser marking systems, and Rofin Sinar's capabilities and resources.

Rofin Sinar, Inc.
For More Information Write In No. 350



ADVANCED ION LASER SYSTEM

The Innova® 300 uses onboard CPU control to automatically maintain optimum laser performance. This CPU also provides extensive control features and in-depth diagnostic capabilities to help you maximize your productivity. The Innova 300 provides output power of up to 10 watts with spectral coverage from the IR to the UV.

Coherent Laser Group
For More Information Write In No. 351

MC4013 CCD MATRIX CAMERA

The EG&G Reticon 4013 camera family consists of high-resolution CCD matrix cameras that cover the full range of 1024 x 1024 CCD camera functionality. The 4013 camera series comes in different configurations covering analog and digital outputs with frame rates to 30 fps. The family employs a full-frame 1024 x 1024 pixel CCD sensor that features high dynamic range, low noise, and low current. 345 Potrero Ave., Sunnyvale, CA 94086.

EG&G Optoelectronics — Reticon
For More Information Write In No. 352

SOLID-STATE RECIRCULATING CHILLERS

ThermoTek's revolutionary recirculating chillers offer solid-state cooling from -10 °C to 30 °C with capacities from 350 watts to over 700 watts. Applications include: laser cooling, immersion cooling, constant temperature baths, condenser cooling, and semiconductor process control. ThermoTek's chillers are 50% lighter than compressor-based systems and use no ozone-depleting refrigerants. Tel: 214-233-6293; Fax: 214-233-5779.

ThermoTek, Inc.
For More Information Write In No. 353

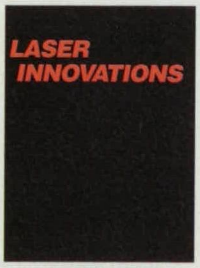
Burleigh Instruments' new Personal SPM series of AFM, STM and UHV/STM systems are designed to make this technology affordable and practical for use in broader areas of application throughout industry and research. Personal SPM systems incorporate innovative technology engineered to reduce the cost of high performance, and with simplified operational features to permit productive use by scientists, engineers, and technicians alike. Burleigh Personal SPM systems are easy to operate and provide high resolution imaging and precise 3D measurement of surface features. Tel: 716-924-9355.

Burleigh Instruments
For More Information Write In No. 354

ADVANCED INTEGRATED DIODE LASERS

A 4-page 4-color brochure describes Visible Laser Module (VLM™) technology, a breakthrough in laser diode miniaturization. Unique design maximizes power coupling while providing enhanced durability. Standard output is visible deep red, but the VLM™ is also available in a variety of power outputs and wavelengths, including IR. New products for 1994 include a 635-nm visible laser module and a 635-nm line generator. Tel: 503-474-6560; Fax: 503-476-5105.

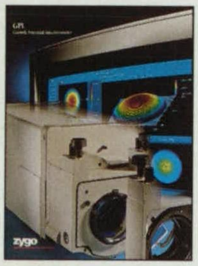
Applied Laser Systems
For More Information Write In No. 355



ION LASER REPAIR

Laser Innovations offers sales, repair, support, and rental of ion laser systems. Specializing in the repair of Coherent lasers, Laser Innovations stocks remanufactured Innova plasma tubes for fast and reliable support of your laser system. Laser Innovations, 688 Flinn Ave., #22, Moorpark, CA 93021. Tel: 805-529-5864; Fax: 805-529-6621.

Laser Innovations
For More Information Write In No. 356



WE MEASURE UP....

...and down and sideways, any way you want. The new Growth Potential Interferometer (GPI) can measure flatness, radius of curvature, sphericity, surface quality, and transmitted wavefront. Upside down, right side up, or on its side, GPI gives affordable measurements of your lenses, mirrors, and windows. The GPI family is designed for growth potential to suit the user's needs. The new line of interferometers replaces Zygo's industry-standard Mark/PTI series, incorporating many of the best features from both lines.

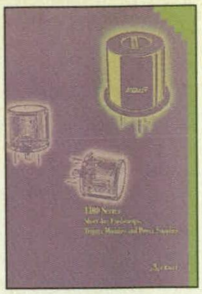
Zygo Corporation
For More Information Write In No. 357

PHOTONICS SHORT-FORM CATALOG

EG&G Vactec has published a new, easy-to-read short-form catalog featuring its full line of commercial-grade optoelectronic components and subassemblies. The products include silicon photodiodes, optoswitches, CdS photocells, analog optoisolators, and IR emitters and phototransistors. A brief listing of typical applications along with detailed electro-optical characteristics and packaging options is illustrated for each product family.

EG&G Vactec

For More Information Write In No. 358



SHORT-ARC FLASHLAMP BROCHURE

EG&G Electro-Optics has published a 15-page brochure featuring the 1100 Series™, its newest family of xenon short-arc flashlamp and power supply components. In-depth technical descriptions address lamp construction, theory of operation, power supply characteristics, envelope and window transmittance, arc intensity profile, electromagnetic noise, and spectral distribution. Life data, arc stability, flash duration, rise time, delay, and jitter are also defined.

EG&G Electro-Optics

For More Information Write In No. 359

LASER DIODE OEM SYSTEMS

Power Technology's new catalog features its complete line of high-quality diode laser systems and components. All systems are fully integrated to include optics and diode-driving electronics. The full product line includes wavelengths from 635 nm to 1550 nm, anamorphic and astigmatic correcting optics, modulation to 20 MHz, precise beam pointing, thermoelectric control, and many mechanical and electrical accessories. Tel: 501-568-1995; Fax: 501-568-1994.

Power Technology, Inc.

For More Information Write In No. 360

OPTICAL THICKNESS GAUGING SYSTEM

Polytec's color brochure describes the DIP-150, a noncontact, laser-based sensor system designed to make on-line optical density measurements of opaque materials such as metal foil, dense paper, cardboard, thick foam, and plastic extrusions. From this, properties such as thickness, density, composition, and concentration can be easily determined. Tel: 714-850-1835; Fax: 714-850-1831.

Polytec PI, Inc.

For More Information Write In No. 361

OPTICAL DESIGN SOLUTIONS USING ASPHERICS

This four-page full-color brochure from Tinsley Laboratories, Richmond, CA, describes its optical fabrication capabilities specializing in reflective and refractive aspheric components. Through these highly useful and versatile optical components, we have opened up new possibilities for optical design, solutions to optical problems, and a broad range of practical applications. Tel: 510-222-8110; Fax: 510-223-4534.

Tinsley Laboratories

For More Information Write In No. 362

MODEL PD-300 PHOTODIODE LASER POWER METER

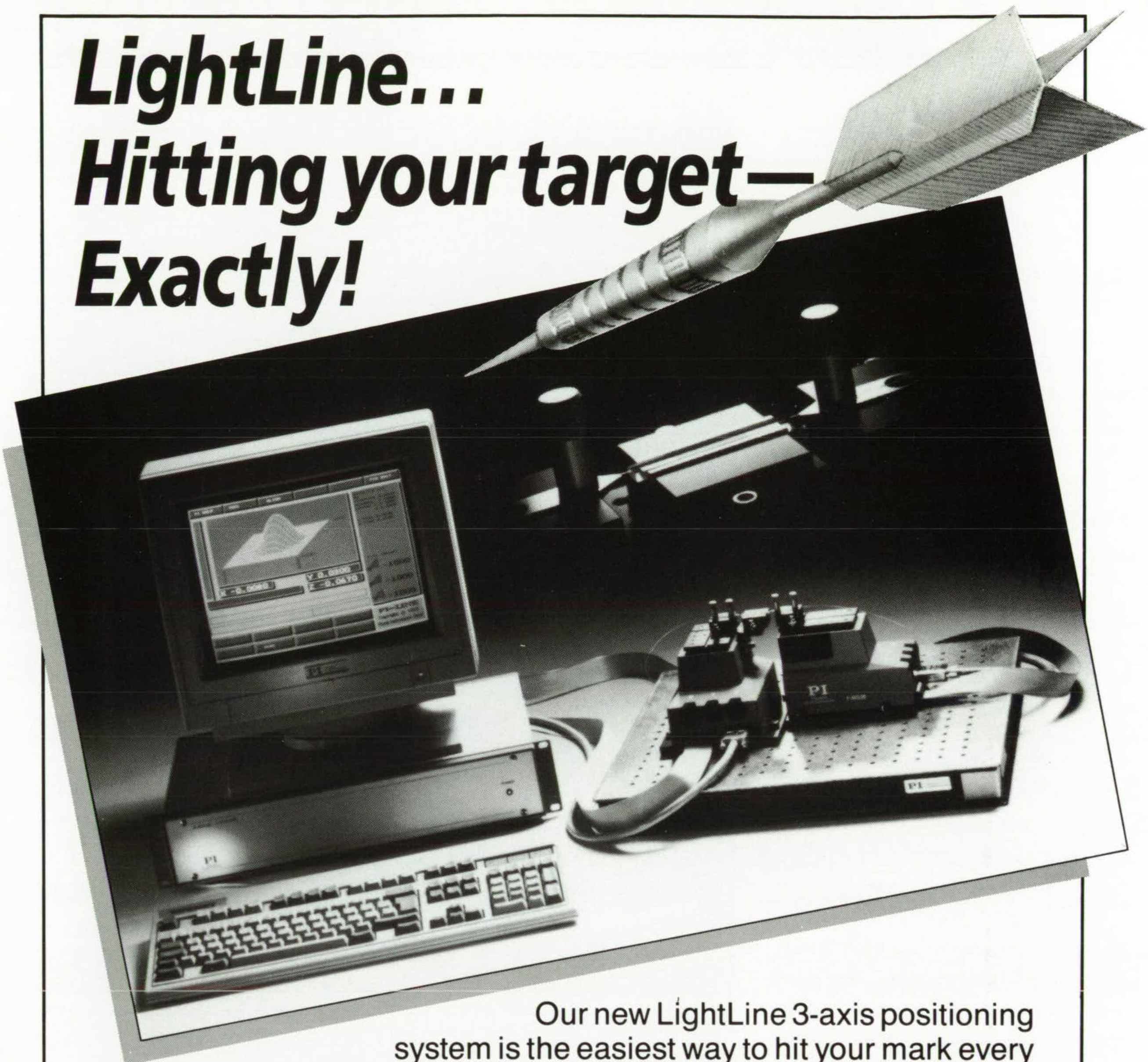
Ophir Optronics, Inc. introduces the Model PD-300 photodiode laser power meter. The Model PD-300 offers interchangeable probes to provide spectral coverage from 250 nm to 1800 nm. It also offers automatic background subtraction with a measurement range from 10 nW to 300 mW.

Ophir Optronics, Inc.

For More Information Write In No. 363

Advertiser Index

LightLine...
Hitting your target— Exactly!



Our new LightLine 3-axis positioning system is the easiest way to hit your mark every time. Using a single drive for each axis, LightLine provides both fine and wide range motion with ten nanometer accuracy over a six mm range. All three axes are closed loop controlled with any PC-compatible computer, in steps as small as one nanometer. LightLine incorporates our Piezowalk[PP] drive, integrated absolute sensors and total digital control to create the ideal fiber optic positioner. It's perfect for a wide variety of development and manufacturing applications including single and multi-mode fiber alignment, source and detector fiber coupling, integrated optical electronics and other projects requiring precise, computer-controlled alignment. A 3-axis angular option is available. For more information, call or Fax us today. Polytec PI. We have the drive to hit the target.

Polytec PI

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Auburn, MA 01501
Tel: + 508 832 3456 FAX: + 508 832 0506